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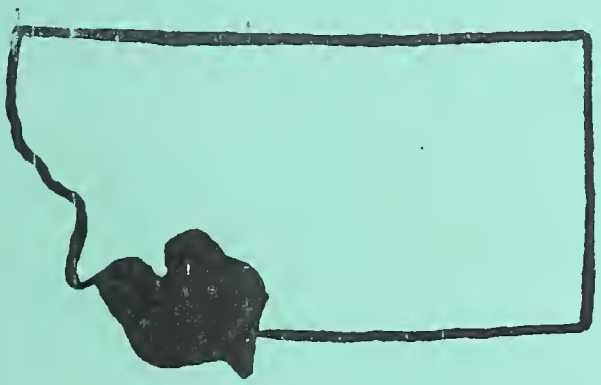

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WATER QUALITY BUREAU
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WATER QUALITY INVENTORY AND MANAGEMENT PLAN
UPPER MISSOURI TRIBUTARIES BASIN, MONTANA

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WATER QUALITY INVENTORY AND MANAGEMENT PLAN
UPPER MISSOURI TRIBUTARIES BASIN, MONTANA

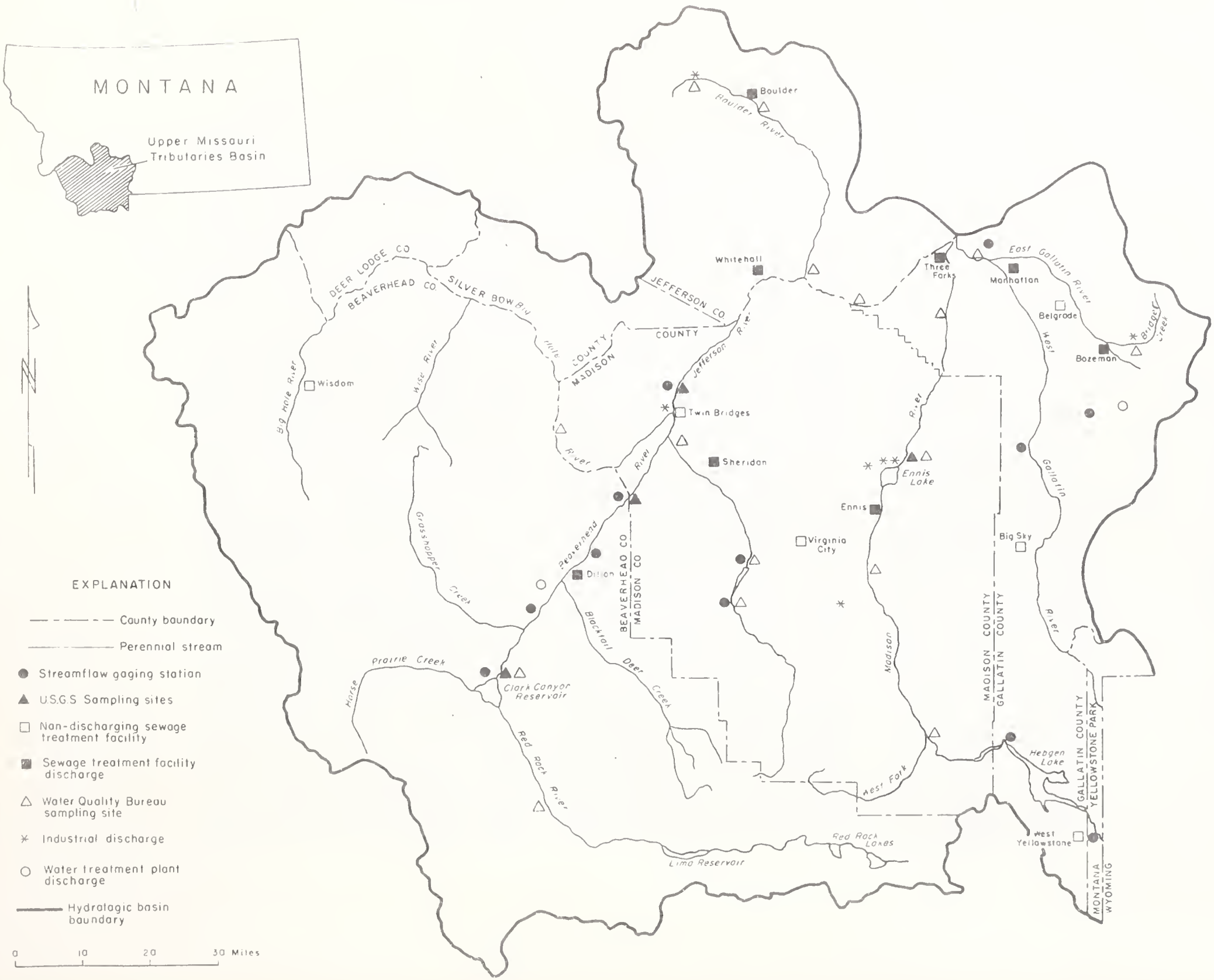
I. INTRODUCTION

This report presents water quality and water quality related information in the Upper Missouri tributaries basin (Figure 1 and Plate I). The Upper Missouri tributaries basin is one of sixteen basins designated by the state of Montana for preparation of water quality management plans. The Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500) have directed states to prepare such plans as part of a nationwide program for controlling water pollution.

The primary purpose of this report is early delineation of apparent water quality and water quality related problems. For this reason, considerable time is spent discussing factors affecting water quality (Figure 2). It is particularly important to note that events occurring within one category may become measurable only after passing through one or more intermediate steps. This approach will permit early formulation of in-depth studies for specific problems. In-depth studies are necessary precursors to development of plans for problem correction. History indicates many uses of streams, particularly fisheries, are lost so slowly that little notice is taken.

Secondary objectives of this plan are to provide the state with water quality data and related information to (1) determine water quality characteristics of all natural and waste waters, (2) develop a management strategy for maintaining and enhancing the quality of waters in the basin, and (3) provide information needed to determine whether Montana's water quality standards are being met and will continue to be met. Also included is a description of physical characteristics of the basin. General methodology used in this study was the compilation and evaluation of existing water quality data and related information. Where information was deficient, field investigations and water and

Figure I — Sketch map showing Upper Missouri Tributaries Basin



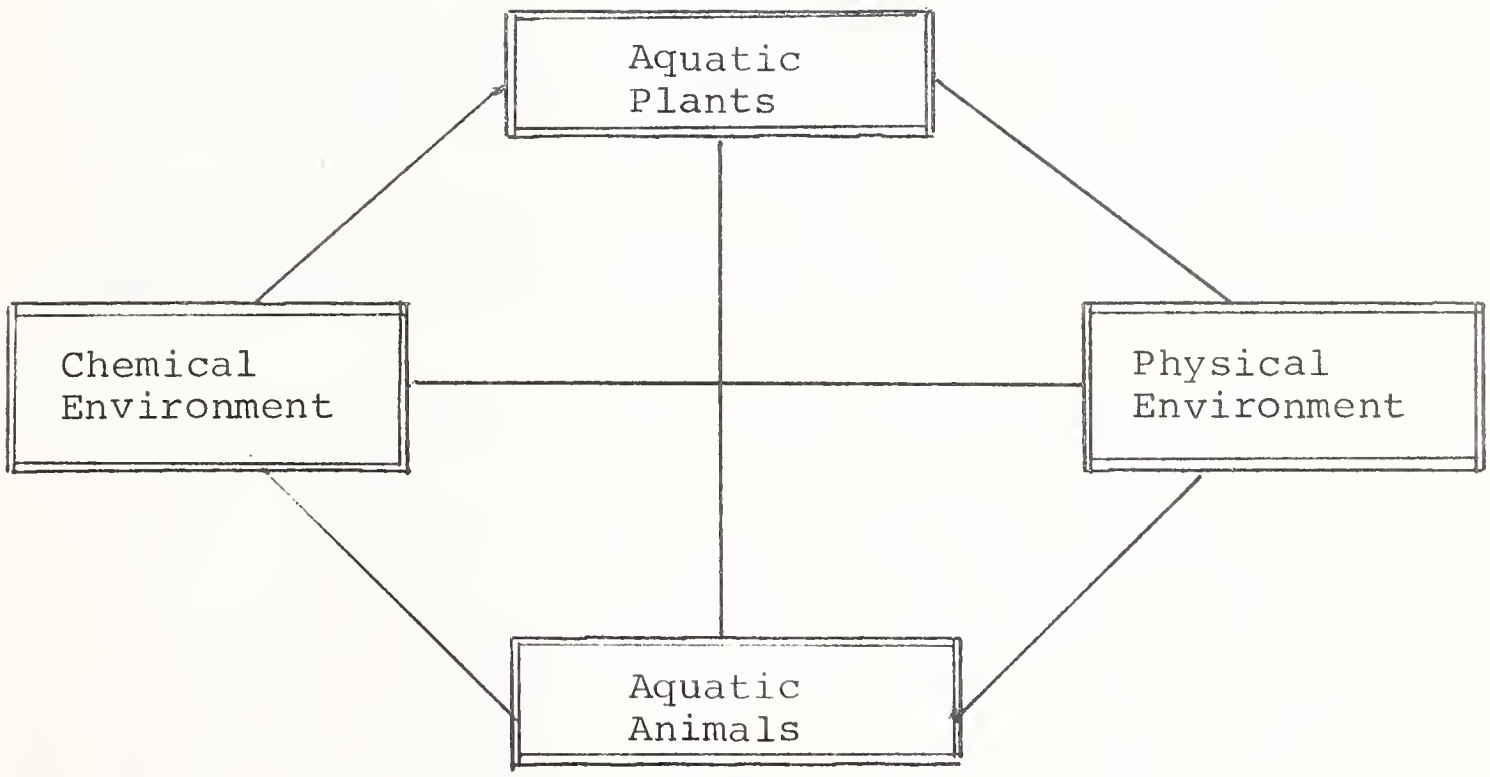


FIGURE 2. RELATIONSHIP BETWEEN WATER QUALITY AND WATER QUALITY RELATED SUBJECT

wastewater sampling and analyses were conducted to obtain needed information.

This investigation does not present a detailed analysis of the area's resources but summarizes water quality related information. As additional information becomes available, the Upper Missouri tributaries basin water quality management plan will be revised and updated as part of Montana's continuing planning process.

Assistance in obtaining information for this report was obtained from a number of agencies and persons. The Montana Department of Natural Resources and Conservation provided information on land use, water use, economy and population. Federal waste discharge permit information was obtained from Richard T. Montgomery, U. S. Environmental Protection Agency State Engineer for Montana. The Montana Department of Fish and Game supplied fisheries information.

Abbreviations and symbols used in this report are defined when first used and again defined in Appendix A.

II. SUMMARY AND CONCLUSIONS

Non-point sources related to land use are the most serious water quality problems in the Upper Missouri tributaries basin. Logging, overgrazing, stream hydrograph manipulation by reservoir storage, increased subdivision development, and irrigation have been identified as important factors which affect or may affect water quality in the basin.

There are 11 municipal, seven agricultural, and four industrial dischargers in the Upper Missouri tributaries basin. Permits have been issued under the joint state-federal discharge permit system for 16 of these discharges. Permits for the remaining six are pending. Compliance schedules have been established for seven municipal and no industrial discharges, and secondary treatment is required of municipal discharges by July 1, 1977. In addition, effluent discharged from the Bozeman sewage treatment plant must meet more stringent limitations by July 1, 1977.

Even with the application of best practicable and secondary treatment to industrial and municipal discharges, respectively, all waters in the Upper Missouri tributaries basin will not meet water quality standards. Grasshopper Creek will remain water quality limited due to high sediment loads from adjacent land. The Madison River will remain water quality limited because of high arsenic and fluoride concentrations attributed to thermal springs in Yellowstone National Park. The Boulder River from Basin, Montana, to the USGS station near Boulder, Montana, plus its tributaries Cataract and High Ore Creeks, should be redesignated water quality limited because of high toxic metals concentrations which have caused serious degradation of the indigenous biological community. Based on a waste load allocation study by Stuart, et.al. (July 25, 1974), water quality standards for the Gallatin River drainage probably will be met when the sewage treatment plant for Bozeman, Montana is upgraded to secondary treatment standards.

Several communities in the basin need to upgrade their sewage treatment facilities if treatment standards are

to be met. As a result, facilities planning is underway in most basin communities. Total estimated cost (including facilities planning) to achieve required treatment levels for public sewage treatment facilities in the basin is $7,301,000.

A surveillance plan for continued monitoring of water quality in the Upper Missouri tributaries basin is described in this plan.

III. RELATED INVESTIGATIONS AND PLANS

TECHNICAL INVESTIGATIONS

Numerous water quality and water quality related investigations have been conducted on streams in the Upper Missouri tributaries basin. Most of these have been associated with master's or doctoral research through the Montana university system (Table 1).

Physical, chemical, bacteriological, and biological surveys in the Upper Missouri tributaries basin were conducted from October 1959 to September 1961 (Montana State Board of Health, 1960, 1961). Data contained in these reports are of limited usefulness due to changes in the drainage and limited sampling. Numerous field investigations and studies have been conducted by the Montana Department of Health and Environmental Sciences and the Montana Department of Fish and Game. Studies and field investigations which pertain to this report are discussed in Sections VIII and IX.

The Montana Water Resources Board (now the Montana Department of Natural Resources and Conservation, Water Resources Division) has published water resources surveys for all counties in the Upper Missouri tributaries basin. These surveys are concerned primarily with existing and potential irrigation development and contain considerable data. Applicable sections of these surveys are discussed in Sections IV and VIII.

The Montana Department of Planning and Economic Development published county-wide water and sewer plans for all counties in the Upper Missouri tributaries basin. These plans delineate existing and future water and sewer collection and treatment facilities for all communities in the Upper Missouri tributaries basin. Applicable portions of these surveys are discussed in Section VI.

An interim water quality management plan has been written for the Missouri River basin above Ervin Ridge (Montana Department of Health and Environmental Sciences, January 25, 1972).

TABLE 1. TECHNICAL INVESTIGATIONS IN THE UPPER MISSOURI TRIBUTARIES BASIN

AUTHOR	LOCATION	PURPOSE	CONCLUSIONS
Lisle (1972)	West Fork of the Madison River	Erosion and sediment transport in the West Fork drainage	The problem was increased water yields due principally to past overgrazing by sheep. Author recommended present sheep grazing be phased out to promote re-establishment of vegetation. Cattle use in the area is limited.
Martin (1967)	Hebgen Lake	Limnology	The lake is a sodium-bicarbonate water body with relatively low concentrations of other major ions. The average annual drawdown of 20 feet limits productivity to the open-water or plankton communities.
Paullin (1973)	Redrock Lakes National Wildlife Refuge	Distribution abundance, phenology, and successional trends of submerged macrophytes plus chemical and physical factors of the soils and waters which regulate their distribution and productivity	Lake bottom soils were found to be very fertile with high concentrations of available calcium, magnesium, potassium, fluoride and organic matter, but low in available sodium and phosphorus. Bottom sediments were easily resuspended by wave action, particularly in shallow, wind-swept upper Redrock Lake.
Smith (1973)	Beaverhead River	Effects of Clark Canyon Reservoir on the limnology of the Beaverhead River	Limnological effects of Clark Canyon Reservoir on the Beaverhead River downstream of the reservoir were: diurnal temperature variations were damped; annual flow pattern of the river was changed greatly; turbidity was decreased somewhat as some sediment was trapped in the reservoir; chemical parameters altered by the reservoir were increased pH, dissolved oxygen, ammonia, and nitrate levels; periphytic forms were much less below the reservoir than in the tributaries above while the opposite was true of planktonic forms; and zooplankton were much higher below the dam than in the incoming tributaries.

AUTHOR	LOCATION	PURPOSE	CONCLUSIONS
Hsiesh (1972)	Gallatin River Drainage	Investigate sediment sources in the Gallatin River drainage	The Taylor Fork was the main source of sediment to the West Gallatin River, while bank erosion along the East Gallatin River was an important sediment source. Numerous small tributaries in the West Gallatin River upstream of Gallatin Gateway also contribute varying amounts of sediment.
Asheim (1973)	Porcupine Creek drainage (near Big Sky, Montana)	Soils mapping of the Porcupine Creek drainage; soils characteristics were related to possible environmental problems in the drainage; and the impact of logging in the drainage was assessed	Sediment yield from the Porcupine Creek drainage would be increased 47 percent (to 8.7 tons per day) if 15 percent of the drainage were logged under strict supervision.
Pierce (1963)	Warm Springs Creek (Ruby River tributary)	Fish distribution in relation to temperature	Rainbow and cutthroat were common above entry of the Warm Spring where the maximum temperature was approximately 60° F and the minimum temperature was approximately 32° F. Mottled sculpins were also abundant in this upstream section. Longnose dase, stonecats, longnose, white and mountain suckers exhibited a preference for the warmer stream temperatures below the entry of the Warm Springs. Average temperature in this section was approximately 70° F.
Burns (1973)	West Fork of the West Gallatin River	Factors affecting stonefly distribution	Major factors affecting distribution of stonefly larvae were substrate, food, and stream temperature. Effects of channelization on population appeared only temporary as subsequent recolonization to former levels was obtained.
Dunkle (1955)	West Gallatin River	A discussion of irrigation usage of the West Gallatin River downstream of Gallatin Canyon	The most productive portion of the West Gallatin River is from the canyon mouth downstream. In 1950, a two-mile section of the river immediately upstream of Central Park was dewatered for irrigation. There are several photos showing manipulated channels, equipment in the stream, and dewatered sections. Author notes that many channel changes have been made in the past two years.

AUTHOR	LOCATION	PURPOSE	CONCLUSIONS
Stuart, et.al (1974)	Big Sky of Montana	Impacts of large recreational developments upon semi-primitive environments	Flow, chemical, and physical aspects of the West Fork of the West Gallatin River, except for suspended sediment, were essentially unchanged by Big Sky construction activities. High turbidities were noted in 1971 during the peak construction season at Meadow Village. Construction related impacts will be minimal compared to people related impacts that will accompany facility use and use of the surrounding environment. One resort leads to another, requiring more roads, more schools, more police and fire protection, and additional energy sources. Over-time, older uses, such as fishing, hunting, tent camping, picnicking, and sight-seeing, will be displaced as the character of the environment is displaced.
EPA (1972)	Madison River drainage in Yellowstone National Park	Measurement of physical, chemical, and biological quality of Yellowstone National Park waters	Stream benthos and periphyton reflected excellent water quality. Flora and fauna of streams have remained essentially unchanged since the first intensive study in 1929. Average arsenic level in the Madison River near the west entrance was 0.22 mg/l; U. S. Public Health Service limit is 0.05 mg/l. Thermal springs in the Norris Geyser Basin and Old Faithful areas are presumed sources.
Klages (1972)	Gallatin River drainage	Sediment sources in the Gallatin River drainage (see entry under Hsiesh)	A 60 percent increase in suspended sediment load was observed in the West Gallatin River between the Forest boundary and Manhattan during the period May through June 1970, indicating serious bank erosion in this reach.
Stuart, et.al. (1974)	Gallatin River drainage	Waste load allocation study	Significant biological improvement in the East Gallatin River has occurred since start-up of Bozeman's expanded wastewater treatment plant in 1970. Limits have been proposed for BOD5, total inorganic nitrogen, total ammonia, nitrite, and total phosphorus for effluent from Bozeman's sewage treatment plant.

AUTHOR	LOCATION	PURPOSE	CONCLUSIONS
Horpestad (1969)	Madison, Firehole and Gibbon Rivers in Yellowstone Park	Aquatic plant community composition and diversity was correlated with physical and chemical parameters of stream.	Major factors affecting plant distribution were substrate and stream point flow velocity. CO_2 concentration was a minor factor.
Kathrein (1948)	Yellowstone Park	Cultivation methods of sulphur bacteria in thermal waters were studied.	Attempts to obtain pure cultures of sulphur bacteria were less successful. However, data collected indicated sodium sulfide is an essential metabolite for growth and cultivation of sulphur bacteria.
Rasmussen (1968)	Firehole River (Yellowstone Park)	Relationship between composition and structure of macrophyte vegetation and physical and chemical factors was studied.	Current and bottom type were responsible for vegetative occurrences but not community diversity. Temperature and alkalinity were variables explaining community diversity.
Roeder (1966)	Madison River (Yellowstone Park)	Diatom community composition was correlated with changing physical parameters and competition.	The distribution of diatom communities is related to water chemistry. Stations with highest alkalinities and conductivities had highest primary productivity.
Spindler (1954)	West Gallatin River	Game fish loss was correlated with physical characteristics of irrigation systems.	Highest gamefish losses were associated with canals diverting greatest flows and with intakes located on river bends. No correlation was apparent between legal gamefish loss and other physical characteristics of canals studied.
Todd (1967)	Madison River (Yellowstone Park)	Primary productivity was studied.	Decreases in CO_2 concentration was of primary importance in accounting for decreased primary productivity with increasing downstream distance.
Arneson (1969)	Quake Lake	To correlate primary productivity with physical and chemical parameters.	Productivity appeared to be limited by phosphate concencentration.
Bierley (1966)	Yellowstone Park	Microbiological study of acid thermal waters of the Geyser Spring Group.	Chemosynthetic autotrophic bacteria appeared to be active in causing water chemistry changes of the two hot spring drainages studied. Most notable appeared to be increased salt concentrations as a result of solubilization of minerals by the direct action of acid produced when bacteria oxidized iron and sulphur compounds. An unusual chemosynthetic autotrophic sulfur-oxidizing bacterium was isolated from one of the drainage.

AUTHOR	LOCATION	PURPOSE	CONCLUSIONS
Clothier (1952)	West Gallatin River	Fish loss and movement in Irrigation Diversions from the West Gallatin River were studied.	Author estimated 1,186 lbs of gamefish were lost to 11 irrigation canals along a 20-mile (Canyon mouth to Irwin Bridge) stretch of the W. Gallatin R. Annual fisherman harvest for this segment was about 10,800 lbs of gamefish.
Garrett (1973)	Middle Fork of West Gallatin River	Major factors affecting species distribution were surveyed.	Food, ice cover, temperature, stream size and substrate were the apparent major factors.
Gumtow (1954)	West Gallatin River	Investigate relationship between periphyton community composition and physical characteristics of the river at Shedd's bridge.	Three divisions of algae representing 34 species and 5 phyla of animals representing 35 species were found in periphyton. Chrysophyte was the most abundant algae and Diptera was the most frequently represented animal Diatom. Diatoms, blue-green and green algae increased in number during the period of high temperatures (late summer). Turbidity and discharge were low in late summer. Algae density was greatest on portions of stones where velocity was least (upstream half).
Heaton (1969)	Madison River (Yellowstone Park)	Benthos and drift fauna of a riffle were evaluated.	A total of 55 different organisms were identified from benthos samples. Ephemeroptera, Plecoptera, Coleoptera, Odonata, Diptera and Trichoptera made up 89% of number and 93% of volume of all benthos. Aquatic invertebrates and emerged aquatic insects made up 92.1% of total volume of drift.
Logan (1975)	West Gallatin R. drainage	Sediment sources and causes and the effects of logging on sediment yield were studied.	This is an active program.

AREAWIDE WASTE TREATMENT MANAGEMENT PLANS

Blue Ribbons of the Big Sky Country Areawide Planning Organization has received a grant for $475,000 under section 208 of the Federal Water Pollution Control Act Amendments of 1972 to maintain and enhance water quality in the Gallatin and Madison River drainages. Planning efforts will begin in July, 1975. The grant will provide funding for 24 months.

SECTION 201 FACILITY PLANS

Plans with grant assistance are being prepared for the communities of Dillon, Whitehall, Sheridan, Three Forks, Manhattan, Bozeman, Ennis, and Big Sky. Willow Creek and Amsterdam-Churchill are preparing facility plans without a grant; however, the methodology has been approved by the Montana Department of Health and Environmental Sciences. Sewage treatment facilities at Belgrade have been completed; there are no additional needs at Belgrade. Sewage treatment facilities at Virginia City essentially are complete; however, the final grant payment has not been made.

LEVEL B PLANS AND OTHER FEDERAL PLANS

A seven-volume study entitled the MISSOURI RIVER BASIN COMPREHENSIVE FRAMEWORK STUDY (1971) is the only federal-state study which has been made for the Missouri River drainage. The Upper Missouri tributaries basin is included in the Upper Missouri sub-basin of the federal-state study. A Level B plan encompassing the Upper Missouri tributaries basin was started under the Western United States Water Plan but not completed because of budget cuts. Status of the plan is unknown. Type IV planning in Montana is administered by the U. S. Department of Agriculture. Type IV planning has not been initiated for the Upper Missouri tributaries basin.

IV. BASIN PHYSICAL CHARACTERISTICS

The Upper Missouri tributaries basin (Plate I), which includes southwestern Montana and northwestern Yellowstone Park, is characterized by several large and distinct mountain ranges separated by broad, flat agricultural valleys with extensive irrigation development. The basin is drained by the Gallatin, Madison, and Jefferson rivers, which join to form the Missouri River near Three Forks, Montana (Plate I). All of Beaverhead and Madison counties, most of Gallatin County, and portions of Park, Broadwater, Jefferson, Silver Bow, and Deer Lodge counties (Plate I) make up the basin. Eight sub-basins comprise the Upper Missouri tributaries basin. These are the Red Rock, Beaverhead, Big Hole, Ruby, Madison, Gallatin, Jefferson, and Boulder River drainages. Population in the basin has been sparse but strongly tied to agriculture; however, agricultural dominance is declining (Stuart, et. al., 1974). Aesthetic qualities of the basin have resulted in a significantly increased tourist and recreation-based industry in recent years and in the attraction of many new residents within the last five years.

CLIMATE

Peak precipitation occurs in May and June followed by a second lesser peak in September. November through February is the driest portion of the year. Heaviest precipitation occurs on the western or windward slope of the mountains. Precipitation in the Upper Missouri tributaries basin is in the 12 to 20 inches per year range in the valleys; however, precipitation in the mountains is much greater (Water Resources Survey for Madison County, 1954). Skies are often cloudy, and frequent periods of showers or general rains occur in spring months. Summer and early fall months are characterized by long periods of clear, sunny weather. General rains are uncommon during this period. The growing season is short--generally varying between 90 and 120 days. Freezing temperatures may occur as late as mid-June and as early as the first week of September. The movement of cold Arctic air masses into the Upper Missouri tributaries basin in winter months may result in below zero temperatures for several days at a time.

There are 42 operating weather stations in the basin (Table 2). Precipitation and temperature records for stations at Bozeman (Montana State University) and Lima (Figure 3) are representative for the basin.

TABLE 2. WEATHER STATIONS IN THE UPPER MISSOURI TRIBUTARIES BASIN

Station Name	Years of Record Temperature	Years of Record Precipitation	Gage Type
Alder	-	14	Non-recording
Alder 17S	16	16	Non-recording
Anceney	-	20	Non-recording
Apex 2 NW	-	22	Non-recording
Basin 3W	-	2	Non-recording
Basin 16 WSW	-	26	Storage
Belgrade FAA AP	31	31	Recording
Boulder State School	38	38	Non-recording
Boulder 15 S Whitetail	-	25	Storage
Bozeman Montana State University	91	95	Non-recording
Bozeman 6W Exp. Farm	7	7	Non-recording
Bozeman 12 NE	21	22	Non-recording
Cameron	-	35	Recording
Clark Canyon Dam	-	25	Recording
Dillon FAA AP	32	32	Recording
Dillon WMCE	73	78	Non-recording
Dillon 9 SSE	-	25	Recording
Divide 2 NW	24	24	Recording
Elkhorn Hot Springs	-	35	Recording
Ennis	53	54	Non-recording
Gallatin Gateway 9SSW	-	22	Non-recording
Gallatin Gateway 26SSW	6	6	Non-recording
Glen	12	14	Non-recording
Grant	-	17	Non-recording
Hebgen Dam	55	58	Recording

Station Name	Years of Record Temperature	Precipitation	Gage Type
Jackson	18	23	Non-recording
Lima	38	50	Recording
Logan	-	8	Recording
Manhattan	-	20	Non-recording
Monida	-	19	Non-recording
Monida 17 NE	-	25	Storage
Monida 13 NNE	-	25	Storage
Norris 3 ENE	14	15	Non-recording
Norris Madison PH	65	66	Non-recording
Pony	13	13	Non-recording
Silver Star	-	25	Non-recording
Twin Bridges	12	22	Non-recording
Virginia City	12	22	Non-recording
Virginia City 22 SSE	-	11	Storage
West Yellowstone	43	43	Non-recording
Wisdom	37	38	Recording
Wise River	-	25	Non-recording

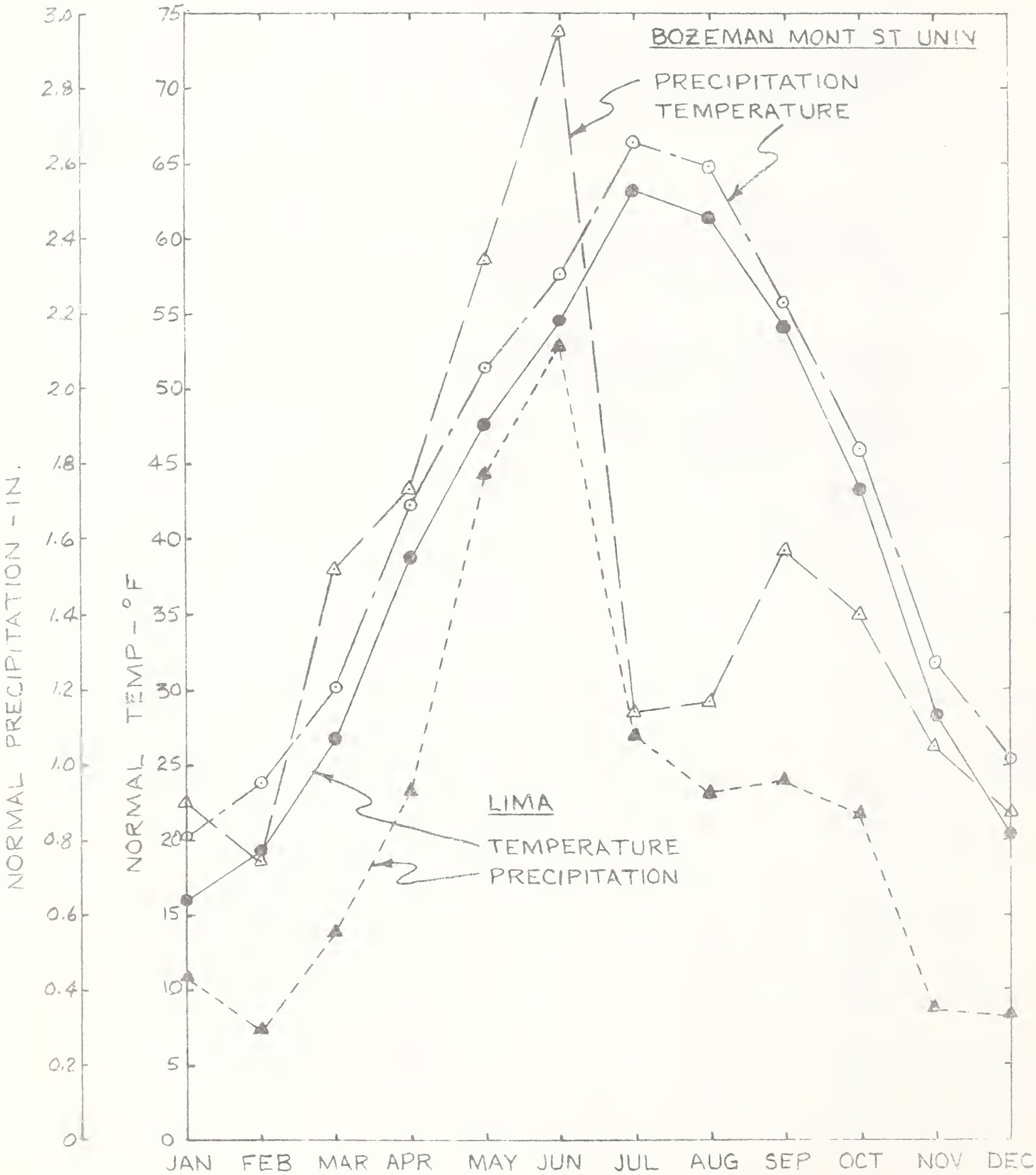


FIGURE 3. TYPICAL NORMAL TEMPERATURES AND PRECIPITATION FOR UPPER MISSOURI TRIBUTARIES BASIN
(Based on NOAA data for Bozeman Mont St Univ and Lima from 1931 to 1960)

HYDROGEOLOGY

Groundwater is available widely in the Upper Missouri tributaries basin and is used for stock, domestic, irrigation, and municipal purposes. Occurrence, availability, and quality of groundwater in the Upper Missouri tributaries basin is related closely to geological conditions. The area has a long and complex geological history and contains a wide variety of rock types of many different geological ages. The basin is characterized by large mountain ranges and broad, alluvial-filled valleys. Geological history of the basin includes long periods of sedimentation, structural deformation, implacement of large instrusive masses, erosion, and glaciation.

Bedrock formations in the basin include a variety of rock types of Pre-Cambrian age (over 600 million years old). These Pre-Cambrian rocks outcrop in mountain ranges in the basin but generally yield little water to wells, except in fractured zones where small to moderate quantities of good to excellent quality water can be obtained. A variety of rocks of Paleozoic age (230 to 630 million years old), including shale, sandstone, quartzite, limestone, siltstone, and dolomite, are exposed over broad areas in the mountainous portions of the basin. Generally, groundwater has not been developed in these rocks, but small to moderate quantities of good quality water should be available.

Bedrock formations of Mesozoic age are exposed generally in the same areas as those of the Paleozoic age. Strata of Mesozoic age (65 to 130 million years old) includes sandstone, limestone, shale, and siltstone. Few wells have been drilled into these rocks; however, they are thought to contain small to moderate quantities of good quality water.

Both intrusive and extrusive igneous rock are in the basin in a number of locations, particulatly the mountain ranges. These rocks contain small to moderate quantities of good quality water in fractures and supply water to numerous springs. Very few wells have been drilled into these intrusive rocks.

Sediments of Tertiary age are present over broad areas in valleys along the Ruby, Madison, Jefferson, and portions of the Gallatin and Big Hole and Beaverhead drainages. Tertiary sediments include thick layers of

sandstone, volcanic ash, and unconsolidated to semi-consolidated mixtures of sand, gravel, silt, and clay. Tertiary sediments with thicknesses that range from a few feet to several thousand feet are derived principally from erosion of nearby mountains. In most areas, water yields from Tertiary materials are small but are adequate for stock and domestic use. Tertiary sedimentary rocks yield large quantities of good quality water in some areas.

Glacial deposits of Pleistocene age (20,000 to 1,000,000 years old) are present in higher mountains of the basin. Glacial moraines consisting of compacted mixtures of boulders, gravel, silt, sand, and clay have been deposited in many of the high mountain drainages. These glacial deposits occupy small areas and are of little significance to the basin's groundwater resources. Generally, these formations yield small to moderate amounts of good quality water, and in some areas, they yield large quantities of good quality water to wells. Alluvium of Pleistocene and Recent (less than 20,000 years old) age is present along major streams in the basin. The alluvium ranges in thickness from a few feet to over 1,000 feet and consists of unconsolidated mixtures and layers of sand, gravel, silt, and clay. Alluvial deposits include terrace deposits, outwash fans, and floodwash deposits. Groundwater from the alluvium is widely used as a source of stock and domestic water in the basin.

Two groundwater pollution problems have been identified within the basin. There are acid mine drainages within the basin, particularly in the upper Boulder River watershed (Section VI). Gasoline pollution of groundwater near Bozeman has been investigated, but economic corrections are unavailable. Sewage stabilization lagoons commonly have seepage into the groundwater and create localized areas of groundwater pollution; however, there have been no problems due to lagoon seepage reported for the basin. There are approximately 18 sewage lagoons in the basin.

Septic tank and subsurface disposal of wastes create localized areas of groundwater pollution. Where there are large numbers of septic tanks and individual water supplies using wells, groundwater pollution can occur and lead to public health problems if disposal systems are not properly designed and located. However, there have been no problems of this type reported.

SOILS

Soil groups most widely represented in the Upper Missouri tributaries basin are those developed on forested uplands, the forest grassland ecotone, fans, terraces, and recent alluvium, imperfectly-drained bottomland, and those developed from fine-textured material in the higher valleys and foothills adjacent to mountainous areas.

Fine-textured soils have evolved on large areas of the forested mountain slopes from a mixture of sedimentary and igneous rocks. The clay subsoil is very hard when dry.

Shallow soils have developed over sandstone bedrock on sloping to steep uplands. Stony loams have been formed on stony material derived from quartzite and argillite. Subsoils are a mixture of silt, sand, gravels, and stones and extend to a depth of six feet. Stony loams also have developed over hard dolomitic limestone on steep mountain slopes. They have a nearly white surface layer, a clayey subsoil, and a lime zone at about two feet. Other stony loams, characterized by a reddish-brown horizon just under the mat of forest litter, have been formed over fractured bedrock, which is encountered at depths ranging from 20 to 40 inches.

Generally, loams have been developed on glacial till and outwash. The solum is usually 12 to 20 inches thick. Soils of the forested mountain slopes, especially the finer textured soils, have a water erosion potential. These soils are used mainly for timber production, wildlife, and watershed.

Loamy soils with a gravelly clay loam subsoil have been formed over deep unconsolidated alluvium in the vicinity of the grass-forest ecotone. In the same ecotone, soils with a dark colored surface horizon have been formed over limestone and calcareous bedrock, which generally are encountered at depths of less than 40 inches. These soils are used for range, hay, and some grain production.

Medium textured soils have been formed on Recent alluvium, some of which are imperfectly drained and on older bench edges. Soils on deep calcareous alluvium usually have a thin, platy surface soil which overlies a high calcareous subsoil. At about two feet, gravel accounts for 30 to 50 percent of the volume. Lime coated gravels may extend five feet below the surface.

A thin surface soil overlies calcareous silt loam. Horizons with 30 to 50 percent gravel by volume are encountered at about two feet. A gravel layer in which gravels are coated with lime may extend to five feet. On level to sloping benches, soils are formed on thin deposits of alluvium over weakly consolidated calcareous sediments. Lime accumulations are encountered at 15 inches. Some of these soils are used for grain and hay production; some are irrigated. Wind erosion can present a problem on these soils. Imperfectly drained soils have management problems associated with high groundwater conditions.

Better agricultural soils in the basin have been formed on deep, calcareous silty material, probably deposited by wind. There is a moderate water erosion hazard on these soils.

LAND USE

The Upper Missouri tributaries basin drains about one-third of Yellowstone Park and 14,669 square miles of southwestern Montana. Elevations range from 4,040 feet at the three forks of the Missouri River to peaks exceeding 10,000 feet. Approximate amount of land in the basin by use is given in Table 3. In addition, much of the national forest lands are leased for cattle grazing.

Principal dryland crops are wheat, barley, alfalfa, hay, and oats. Principal irrigated crops are hay, alfalfa, and small grains. An increasingly important land use in the basin is subdivision development.

Soil erosion due to adverse land uses has been identified as a national problem. Loehr (1972) states soil delivery to streams amounts to from 7 to 20 percent of the total soil loss from a site. This is about 4 billion tons of soil per year to streams (Wadleigh, 1968). In 1974, the Montana legislature adopted a joint resolution recognizing soil erosion and resulting sedimentation as a major problem in the state (Section XIII). Ogle and Ross (1972) note 50 percent of the range lands in Montana are being overgrazed; 89 percent, 7 percent and 4 percent of this rangeland is private, federal (5 percent Bureau of Land Management and 2 percent Forest Service), and state owned, respectively. Ogle and Ross (1972) further note adequate amounts of old and new vegetation ensures high rates of water absorption by

the soil. Conversely, overgrazed range has a decrease ability to absorb water, resulting in runoff, sedimentation, and a drouthy soil condition. Musgrave (1947) states rainfall, particularly intensity and duration, flow characteristics of the watershed surface, physical soil properties and vegetative cover are the primary factors influencing sediment to streams.

TABLE 3. LAND USE BY AREA IN THE UPPER MISSOURI TRIBUTARIES BASIN

Use	Area - Square Miles
National Forests	6,200
National Parks	700
National Wildlife Refuge	100
Irrigated Land	914
Dryland Crop	300
Pasture and Miscellaneous*	6,445
Urban	10
TOTAL	14,669

*Miscellaneous includes wasteland, rangeland, roads, water areas, and farmsteads.

Land use needs, soil erosion and sedimentation, and range management for Montana have been discussed by the USDA Soil Conservation Service (1968, 1972) and the U. S. Environmental Protection Agency (February 15, 1974). In addition, each National Forest within the Forest Service system is preparing detailed multiple use plans. For purposes of these plans, the forests are divided into manageable study units. Completion of these plans is expected to take a number of years (Hawkes, November 30, 1973).

Land use in Montana is changing. In a study of the impacts of Big Sky of Montana, Stuart (1974) notes land prices and market activities in the vicinity of Big Sky appear correlated with the development. Stuart (1974) also notes activity near Big Sky is symtomatic of the land rush occurring in western Montana. Construction related impacts are believed to be small compared to people related impacts which will accompany use of recreational facilities and the surrounding environment. The impacts, including water quality changes, due to this rapid land use change is unknown. House Bill 666 of the 1975 Montana legislative session requires disapproval of any subdivisions in the absence of a demonstrated public interest.

Dyrness (1967) and Swanston (1970) consider all of the western third of Montana (includes the Upper Missouri tributaries basin) an area where the risk of mass movement is high. So, land use and land use trends are important. Swanston (1971) notes poor logging practices can be a high risk land use in areas such as the Upper Missouri tributaries basin, noting timber harvest may permit an increase in soil water content and disruption of stabilizing root systems. A Montana Department of Health and Environmental Sciences hearing was held on February 7, 1975, concerning logging practices in a municipal watershed which precipitated a land flow (Section VI).

Costs of correcting erosion and sediment problems resulting from poor land use practices are high, and financing them may not be equitable. The EPA (September 1973) notes the cost of correcting erosion and sediment problems resulting from highway construction and land development often are transferred unjustifiably to the taxpayers. So, the costs of remedial measures may be borne by people other than those benefitting from the project. The Soil Conservation Service (1968) finds costs for adequate stream bank protection of agricultural lands is too high for most private farms and ranches and advocates state or federal assistance.

WATER USE

Major consumptive use in the basin is irrigation; approximately 2.7 million acre-feet are diverted annually. Of this, about 1.9 million acre-feet are delivered to the field where 0.7 million acre-feet is used consumptively by the crops. Approximately 1.4 million acre-feet are returned as return flows.

Annual domestic consumptive use in the basin is about 10,000 acre-feet. Other water usage in the basin is negligible.

DEMOGRAPHY AND ECONOMICS

The Upper Missouri tributaries basin contains all of Beaverhead and Madison counties, most of Gallatin and Jefferson counties, and significant parts of Silver Bow and Deer Lodge counties. Nineteen-seventy census data from county census divisions have been summed to approximate the population and employment of the basin. According to the census, 1970 population of the basin was 63,682 with 32,989 classed as urban and 30,694 classed as rural. Communities considered urban by the census are Dillon, Anaconda, and Bozeman. Communities with 100 or more people are listed in Table 4 along with their 1970 population.

TABLE 4. UPPER MISSOURI TRIBUTARIES BASIN
Communities of 100 or more persons

Community	County	1970 Population
Dillon	Beaverhead	4,548
Wise River	Beaverhead	100
Lima	Beaverhead	351
Wisdom	Beaverhead	154
Boulder	Jefferson	1,342
Whitehall	Jefferson	1,035
Bozeman	Gallatin	18,670
Manhattan	Gallatin	816
Three Forks	Gallatin	1,188
Belgrade	Gallatin	1,307
Gallatin Gateway	Gallatin	200
Willow Creek	Gallatin	150
Amsterdam	Gallatin	100
West Yellowstone	Gallatin	576
Bozeman Hot Springs	Gallatin	100
Ennis	Madison	501
Harrison	Madison	175
Pony	Madison	100
Virginia City	Madison	149
Alder	Madison	125
Sheridan	Madison	625
Twin Bridges	Madison	613

Table 5 gives historical and projected population and total employment for the basin from 1930 to 1985. Basin population has been increasing regularly since 1930 and is projected to continue. With the exception of a decline from 1930 to 1940, total employment has increased during that same period. It is also projected to increase to 1985.

TABLE 5. UPPER MISSOURI TRIBUTARIES BASIN - POPULATION AND EMPLOYMENT - Historical and Projected 1930 - 1985

	1930	1940	1950	1960	1970	1980	1985
Population	46,591	48,386	52,080	57,880	63,682	69,472	72,371
Employment	19,366	17,462	19,743	20,966	23,902	25,696	26,735

Table 6 lists 1970 employment by gross sectors. Agriculture is the most important activity except for category of services and other. The services and other category includes significant governmental employment as well as Montana State University in Bozeman. Agriculture in the region is largely based on livestock with much irrigation devoted to the production of livestock feed. The entire basin has broad scenic vistas with economic recreational activities concentrated near Yellowstone Park, although they also are spread throughout the basin. Big Sky, a ski-based land and recreational development between Bozeman and West Yellowstone is the biggest and most recent such development.

TABLE 6. UPPER MISSOURI TRIBUTARIES BASIN - EMPLOYMENT BY GROSS SECTORS (1970 data)

Sector	Number	Percent of Total
Agriculture	2,977	12.5
Forestry & Fisheries	390	1.6
Mining	379	1.6
Construction	1,368	5.7
Manufacturing	2,595	10.9
Services & Other	16,193	67.7
	23,902	100.0

The economy and people of Montana are inexplicably tied to the state's water resources. Bozeman and Dillon, the basin's largest communities, plus numerous smaller communities, use surface waters for domestic supply. Streams of the Upper Missouri tributaries basin are also important for recreation--Montana's third largest industry. The Montana Department of Highways (December 11, 1974) estimates the recreation industry brought $241 million into the state in 1973. The executive committee of the Montana Task Force on Economic Development considers the tourist (recreation) industry vital to Montana's economy and has recommended that a study be initiated to determine if additional promotional money should be spent (Boles, Winter, 1974).

V. MONTANA WATER POLLUTION CONTROL PROGRAM

Water quality management planning is a part of a broad, comprehensive water pollution control program administered by the Water Quality Bureau of the Environmental Sciences Division. This program is described in the program plan of the Water Quality Bureau (1974). Important elements of the state program are:

1. State and federal waste discharge permit program;
2. Water quality standards;
3. Facilities construction grants, plan review, operation and maintenance inspections, training and licensing of operators;
4. Statewide monitoring and surveillance program;
5. Public participation; and
6. Enforcement.

STATE AND FEDERAL WASTE DISCHARGE PERMIT PROGRAM

The 1955 Montana state law established a waste discharge permit program. A revision of this law in 1967 required a permit for all discharges. Regulations and a formal state permit program were established in 1968 for the discharge of sanitary sewage and municipal wastes to waters of the state. In 1972, a waste discharge permit regulation for confined livestock feeding was adopted by the Board of Health and Environmental Sciences. All operations feeding livestock for marketing purposes within any confined area or enclosure not normally used for raising crops or for pasture, which at any time discharges drainage water to a state water, is required to have a permit. Existing operations and all new or expanding operations are required to have a permit.

The Federal Water Pollution Control Act Amendments of 1972 established a national permit system. Industrial, municipal, and other point source discharges will be required to obtain permits to discharge pollutants into

navigable waters or their tributaries. The EPA (U. S. Environmental Protection Agency) has given authority to allow states to administer the permit program providing the states conform to certain guidelines. On June 11, 1974, Montana assumed most of the federal permit program.

Waste discharge permits are an effective tool for regulating discharge of potentially harmful effluents into Montana lakes and streams. Treatment works will be required to meet specific effluent standards. In most cases, the discharger will be responsible for certain monitoring information; for example, sampling and analysis of the water at specified intervals. In instances where effluent being discharged does not meet state standards, the permit is issued on a "compliance" basis with stipulations as to what corrections will be made and when.

The act also provides that the permit program will achieve, no later than July 1, 1977, effluent limitations for point sources, other than publicly owned treatment works, which shall require the application of best practicable control technology. For publicly owned treatment works, secondary treatment of wastes or any more stringent limitation necessary to meet water quality standards will be required by July 1, 1977. The act further specifies that by July 1, 1983, effluent limitations for point sources, other than publicly owned treatment works, shall require application of the best available technology. Publicly owned treatment works shall achieve best practicable treatment by July 1, 1983.

These steps will result in progress toward a national goal of eliminating the discharge of all pollutants by 1985.

WATER QUALITY STANDARDS

Water pollution control was started officially in Montana in 1907 with the passage of legislation designed to protect domestic water supplies. A law passed in 1955 was more comprehensive. It dealt with the control and protection of water for additional uses--recreation, agriculture, and industry. The law also established a Water Pollution Control Council and charged it with the tasks of classifying all streams in the state according to their most beneficial uses and establishing water quality criteria for the streams. It also involved upgrading the treatment of wastes going into the streams. Montana, thus, became one of the first states to have enforceable stream classifications.

In 1965, the U. S. Congress passed the Federal Water Quality Act, which required that all states classify and establish water quality criteria for their interstate streams by July 1, 1967. This resulted in Montana revising its standards for both interstate and intrastate waters and required a higher degree of stream quality than before. Secondary treatment or the equivalent was required by municipal and industrial discharges. Primary treatment or the equivalent was required before passage of the act.

In October, 1972, the Federal Water Pollution Control Act Amendments were passed by Congress, expanding the authority of the Environmental Protection Agency. Uniform water quality standards and enforcement procedures throughout the United States is the objective. For example, industrial waste dischargers throughout the nation manufacturing the same product will have uniform discharge requirements, based on the amount of product produced. Again, Montana was required to revise its water quality standards. The Department of Health and Environmental Sciences adopted revised standards on July 13, 1973 (Appendix B). The new standards became effective in November, 1973.

Montana water quality standards serve as a functional tool in protecting water quality; however, there are a number of laws, statutes, and regulations which complement the water quality standards and significantly assist in protecting water quality.

STATEWIDE MONITORING AND SURVEILLANCE PROGRAM

Prior to 1972, Montana had done little monitoring due to lack of funds. With increased appropriations provided by the 1971 legislature and the federal government, the state greatly increased its efforts. Staff were added, and laboratory equipment purchased. The present state monitoring program includes periodic compliance monitoring of municipal and industrial wastes, long-term baseline monitoring of streams, and a statewide program for determining the general quality of all significant surface waters.

The statewide inventory of water quality will identify areas with water quality problems and will provide basic data for water quality management and planning programs. Included in the monitoring is a statewide assessment of the trophic (pollution level) status of Montana's lakes,

reservoirs, and ponds. This program is coordinated with the EPA National Lake Eutrophication Survey.

FACILITIES CONSTRUCTION, OPERATION, AND MAINTENANCE

A minimum requirement of primary treatment for all domestic sewage was first adopted by the Montana Board of Health in 1952. All of Montana's communities have met this requirement, and many of the communities have upgraded their facilities to secondary treatment or are in the process of constructing or planning secondary systems. Since 1956, there has been a federal grant program to assist municipalities in the construction of sewage treatment facilities, including outfall and interceptor sewers. In 1971, the Montana state legislature appropriated $4,000,000 to aid municipalities in construction of these same facilities. The 1973 legislature appropriated $1,600,000 to reimburse municipalities that had proceeded with construction since July 1, 1966, without waiting for state grants. With passage of the Federal Water Pollution Control Act Amendments of 1972, 75 percent of eligible project costs are federally financed. Due to a shortage of federal grant funds, a priority system for fund allocation must be used. The state, under EPA guidance, establishes priorities for proposed waste treatment projects.

An important part of municipal sewage treatment is proper operation and maintenance of facilities after construction is completed. In an effort to improve operation and maintenance, the state has conducted an operators' school each year. During recent years, this school has had about 100 operators attending. In 1971, a grant was obtained from the federal government for employing two training instructors to conduct training programs throughout the state in addition to the annual school.

An operators certification program was established in 1968 following enactment of a law requiring certification of those in responsible charge of a sewage treatment or industrial waste treatment system.

PUBLIC PARTICIPATION

Public participation in water pollution control is an increasingly important aspect of the state program. Public hearings are held concerning proposed regulations, water quality management plans, and waste discharge permit applications where there is substantial

public interest. The state also has an environmental impact statement requirement. Environmental impact statements or agency impact determinations are prepared where substantial public interest is indicated.

The public is also kept informed by means of a Water Pollution Control Advisory Council, which has been established by law to assist the Water Quality Bureau in preparation of rules and regulations and in dissemination of information to interested groups. Similarly, public meetings are attended on request, and a bi-monthly newsletter is published by the Department of Health and Environmental Sciences.

ENFORCEMENT

The 1955 Montana state law provided enforcement procedures. These laws were revised in 1971. They were again revised in 1973 to provide better enforcement and to obtain consistency with the Water Pollution Control Act Amendments of 1972. Three attorneys are now on the staff of the Department of Health and Environmental Sciences; one-half man-year has been allocated to aid in enforcement of water pollution control laws.

VI. WATER POLLUTION SOURCES

Water pollution in the Upper Missouri tributaries basin may be caused by several factors, including municipal discharges, acid mine drainage, runoff from mismanaged and erodible soils, and agricultural wastewaters. The impact of industrial, municipal, and agricultural discharges in the basin is minor. Stormwater and swimming pool discharges and solid waste disposal are not discussed in this plan but are recognized as potentially significant water pollution sources. Most swimming pools discharge to municipal systems, but a small number are believed to discharge to adjacent watercourses.

MUNICIPAL DISCHARGES

There are 19 municipal water and wastewater treatment facilities in the basin (Table 7); of these, 14 discharge or have the capability to discharge wastewater to adjacent streams. The remaining five utilize evaporation and seepage. Lagoon systems are used most commonly to treat municipal sewage; however, mechanical plants are used at Bozeman and West Yellowstone (Table 4). Private septic tanks with drainfields or illicit discharges to nearby streams are used in communities without municipal sewage collection and treatment facilities.

Bozeman and Dillon water treatment facilities utilize sedimentation basins with simple settling to remove suspended solids during spring runoff. The Bozeman basin system functions poorly; retained sediment is flushed to an adjacent irrigation ditch. The ditch returns to Sourdough Creek, but flushing of the basins and peak irrigation demand coincide, so little of the sediment likely reaches Sourdough Creek. Most of the suspended solids removed by the Dillon system are mechanically removed and disposed on adjacent land; remaining solids are flushed to Rattlesnake Creek.

Water for the City of Butte is obtained from three watersheds. Two of these lie west of the Continental Divide, as does Butte, and are discussed in the Water Quality Inventory and Management Plan, Upper Clark Fork Basin, Montana. Third source is the Big Hole River and is

discussed here. Water is diverted from the Big Hole River near Divide, Montana, and pumped to a sedimentation basin-rapid sand filter-holding basin complex. Alum, lime, chlorine and ammonia are introduced at the pump station. Sediment from the sediment basin is removed with front end loaders for disposal on adjacent land. Filter backwash effluent is retained by topography on a nearby flat area well stabilized by vegetation (Young, 1972).

One hundred twenty-six tourist campgrounds and trailer courts in the basin are licensed by the ESB (Environmental Services Bureau, Montana Department of Health and Environmental Sciences). Those not connected to municipal systems utilize adjacent lands for final effluent disposal. Septic tanks with drainfields are the most common treatment facility, but seepage pits, facultative lagoons and aerated lagoons with seepage cells are also used (Peterson, August 2, 1974). Most of the 164 licensed motels and hotels in the basin are not connected to municipal systems and, therefore, use septic tanks with drainfields for sewage treatment (Harbrecht, February 13, 1975).

TABLE 7. MUNICIPAL SEWAGE AND WATER TREATMENT PLANTS IN THE [illegible] MISSOURI TRIBUTARIES [illegible]

[illegible]	[illegible]	[illegible]	[illegible] Permit [illegible]	Location	Type	Receiving Stream	Facility Description	Needs	Dates Sampled	Average Daily Flow - MGD	Type of Discharge	[illegible]	Fecal Coliform /100 ml	Total Coliform /100 ml	Chlorine Residual	Remarks
Bo[illegible]	18,[illegible]	[illegible]	MT-[illegible]	1S6 26A	Activated sludge	East Gallatin River	Existing plant completed in 1970, provides secondary treatment to approximately 50% of influent flow. Treatment includes grit removal, screening and grinding, primary sedimentation, partial secondary treatment, heated digestion and chlorination of final effluent before discharge. Grit is landfilled and digested sludge is pumped to a lagoon for dewatering. Dewatered sludge is landfilled.	Increased secondary treatment capacity is needed.	Daily (city of Bozeman)	[illegible] in winter [illegible] in summer	Continuous	[illegible] (winter) 60 (summer)	275	NM	0.3	Pounds BOD_5 discharged per day and percent removal in winter and summer = 2,000 lbs, 60%, 2,250 lbs and 54%, respectively. TSS discharged = [illegible] mg/l and 625 lbs/day (winter) and 25 [illegible]/l and 940 lbs/day (summer). Winter and summer TSS removals = 75% and 69%, respectively.
[illegible]	[illegible],18[illegible]	[illegible]	MT-[illegible]401	[illegible]	None	Jefferson River	Raw sewage is discharged to the Jefferson River. An existing 18.3-acre lagoon is not in use because a severe infiltration problem is causing wastewater flows greatly in excess of the lift station.	Application has been made for an EPA Step 1 facilities planning grant to assess needs.	Monthly [illegible] to 9/72 and [illegible] to 5/[illegible]	[illegible]	Continuous	4. to 89.	NM	14,000 to 180,000	Chlorination not provided.	None
Belgrade	1,3[illegible]	1,[illegible]	MT-[illegible] Discharge	1[illegible]5E5	Facultative lagoon	None	Four-cell system with capability to operate in a number of different modes. Two cells have surface area of 14 acres. Surface area of other cells is 13 acres. Normal operating depth is five feet.	None. New system completed in 1974.	Facilities inspected 6/19/74		No discharge	0				
Manhattan	81[illegible]	[illegible]	MT-[illegible]2185[illegible]	1N3[illegible]	Facultative lagoon	East Gallatin River	Two-cell (5.5 acres each), series or parallel operation; normal operating depth is five feet; second cell discharges to irrigation ditch and may not reach East Gallatin River.	Infiltration has been a problem. Application has been made for EPA Step 1 facilities planning grant to assess needs.	Monthly 2/72 to 9/72 and 1/73 to 5/73; 12/21/73	[illegible] to 0.6[illegible]	Continuous	6. to 41.	5,600 to 10,000	5,400 to 1,369,000	Chlorination not provided.	Average TSS = [illegible] mg/l
West Yellowstone	[illegible]	[illegible]13	No discharge, permit not issued	13S[illegible]28[illegible]	Activated sludge followed by polishing pond and seepage moats	None	Activated sludge plant consists of single aeration basin with a 9-hour retention time at a design flow of 0.45 MGD followed by two 15,000 gallon parallel operated clarifiers. Effluent from the mechanical plant is discharged to a six-acre polishing pond with a five-foot operating depth. Final disposal is achieved in a 60,000 square foot seepage area. Waste solids are landfilled.	None.	Facilities inspected 6/20/74		No discharge	0				
Ennis	[illegible]1	[illegible]6	MT-[illegible]2136	5S1W33[illegible]	Facultative lagoon	Madison River	Single-cell, 6-acre lagoon with five-foot normal operating depth.	Infiltration has been a problem; application has been made for an EPA Step 1 facilities planning grant to assess needs	Monthly [illegible]	0.04 to 0.06	Continuous	7. to 73	NM(1)	7,200 to 76,000	Chlorination not provided.	None

discussed here. Water is diverted from the Big Hole River near Divide, Montana, and pumped to a sedimentation basin-rapid sand filter-holding basin complex. Alum, lime, chlorine and ammonia are introduced at the pump station. Sediment from the sediment basin is removed with front end loaders for disposal on adjacent land. Filter backwash effluent is retained by topography on a nearby flat area well stabilized by vegetation (Young, 1972).

One hundred twenty-six tourist campgrounds and trailer courts in the basin are licensed by the ESB (Environmental Services Bureau, Montana Department of Health and Environmental Sciences). Those not connected to municipal systems utilize adjacent lands for final effluent disposal. Septic tanks with drainfields are the most common treatment facility, but seepage pits, facultative lagoons and aerated lagoons with seepage cells are also used (Peterson, August 2, 1974). Most of the 164 licensed motels and hotels in the basin are not connected to municipal systems and, therefore, use septic tanks with drainfields for sewage treatment (Harbrecht, February 13, 1975).

Community	Population 1974	Population [illegible]	Discharge Permit No	Location	Type	Receiving Stream	Facility Description	Needs	Dates Sampled	Average Daily Flow - MGD	EFFLUENT CHARACTERISTICS: Type of Discharge	BOD5 mg/l	Fecal Coliforms /100 ml	Total Coliforms /100 ml	Chlorine Residual	Remarks
Virginia City	149	[illegible]	No discharge; permit not issued.	3S3W22B	Facultative lagoon	not applicable	Three-cell, series operated lagoon system. first two cells are 0.83 acres each with design operating depth of five feet; third cell is about one acre and serves as seepage cell. Design flow is 0.015 MGD.	None. This facility completed.	Facility inspected 3/27/74	0	No discharge					
Wisdom	154	11[illegible]	No discharge, permit not issued	[illegible]S3W26	Facultative lagoon	not applicable	Construction of two-cell series or parallel operated lagoon system scheduled for completion in summer, 1974; surface area of each cell is 1.5 acres at operating depth of five feet. Adjacent grassland available for spray irrigation if needed.	None. This facility to be completed summer, 1974.	Facility inspected 4/2/74	0	No discharge					
Sheridan	[illegible]	[illegible]	MT 0022098	4S4W18C	Facultative lagoon	Little Indian Creek	Single-cell with surface area of 6.3 acres at five-foot operating depth.	Infiltration is a problem; application has been made for an EPA Step 1 facilities planning grant to assess needs.	Monthly [illegible] to 9/72, 1/25/73, 3/14/73	Varies from 0.11 in winter to 0.23 during irrigation season	Continuous	5. to 43.	Not measured	43,[illegible] to 1,500,000	Chlorination not provided	
Boulder (Town plus State Training School and Hospital)	1,342	2,[illegible]	MT-0023078	6N4W33DCA	Facultative lagoon	Boulder River	Three-cell lagoon system; first two cells are six acres each and may be operated in series or parallel; third cell has surface area of 6.4 acres and may be operated only in parallel; with first two cells, normal operating depth is five feet.	Correct infiltration, provide secondary treatment	3/73, 5/73, 10/73 (WQB)	0.03 to 0.39 full cells operating in parallel	Continuous	13. to 60.	Not measured	12,600 to 2,500,000	Chlorination not provided	Effluent TSS varied from 75 mg/l to 115 mg/l
Big Sky	0	[illegible]	No discharge; permit not issued	6S3E36	Aerated lagoon	not applicable	Aerated lagoon approximately 0.5 acre with 14 foot normal operating depth	Filtration and chlorination equipment	6/20/74	0	No discharge					Resort just starting. Sewage treatment will consist of aeration and storage ponds, filtration, chlorination and irrigation of final effluent when resort fully developed.
Whitehall	1,055	1,7[illegible]	MT 0020133	1N4W4AAD	Facultative lagoons	Side Channel of Jefferson River	Two cell, parallel operated lagoon system; each cell has surface area of 11 acres and operating depth of five feet.	Extend collection system to portion of town not served	Monthly 1/[illegible] to 9/72 and 3/73 to 5/73	Varies from 0.07 to 0.29	Continuous	6. to 19.	Not measured	[illegible],000 to 150,000	Chlorination not provided	
Twin Bridges	613	766	No discharge; MT-0020885	3S6W22D	Facultative lagoon	None	Two 3-acre cells which may be operated in series or parallel. Normal operating depth is five feet.	None	Facility inspected 4/15/74	0	No discharge				Chlorination not provided	Design population equivalent = 600.
Twin Bridges (State Orphans' Home)	60		No discharge, permit not issued.	3S6W27B	Facultative lagoon	None	Two cells of approximately two acres each may be operated in series or parallel Normal operating depth is five feet.	None	Facility inspected 3/22/74	0	No discharge				Chlorination not provided	Lift station bypass will permit discharge of raw sewage to Jefferson River if pumps fail.
Dillon (sewage)	4,548	5,685	MT 0021458	7S8W08CB	Facultative lagoon	Beaverhead River	Single 36-acre cell with normal operating depth of five feet.	None	Sampled monthly by city of Dillon	0.9	Continuous	20. to 80	NM	17,000 to 1,100,000	Chlorination not provided	Design population equivalent and average design flow are 3,700 and 0.37 MGD, respectively TSS = 80 mg/l (4/4/74).
Dillon (Water)	4,548	5,685	Permit not issued	7S9W15DD	Sedimentation basin	Rattlesnake Creek	Simple settling without chemical additions used. Settled solids are disposed of on adjacent land.	None	Facility inspected 4/2/74		Irregular					Surface water supply with moderate turbidity in spring. Basin manually cleaned as required.

discussed here. Water is diverted from the Big Hole River near Divide, Montana, and pumped to a sedimentation basin-rapid sand filter-holding basin complex. Alum, lime, chlorine and ammonia are introduced at the pump station. Sediment from the sediment basin is removed with front end loaders for disposal on adjacent land. Filter back-wash effluent is retained by topography on a nearby flat area well stabilized by vegetation (Young, 1972).

One hundred twenty-six tourist campgrounds and trailer courts in the basin are licensed by the ESB (Environmental Services Bureau, Montana Department of Health and Environmental Sciences). Those not connected to municipal systems utilize adjacent lands for final effluent disposal. Septic tanks with drainfields are the most common treatment facility, but seepage pits, facultative lagoons and aerated lagoons with seepage cells are also used (Peterson, August 2, 1974). Most of the 164 licensed motels and hotels in the basin are not connected to municipal systems and, therefore, use septic tanks with drainfields for sewage treatment (Harbrecht, February 13, 1975).

Community	Population[4] 1970	[illegible]	Discharge Permit No	Location	Type	Receiving Stream	Facility Description	Needs
Bozeman (Water Supply)	18,670	26,000	Permit not issued	3S6E06DD	Sedimentation basin	Irrigation ditch and thence to Sourdough (Bozeman) Creek	Simple settling without chemical additions used. Settled solids are disposed of on adjacent land.	None
Butte (Water Supply	4[illegible],000	42,[illegible]	MT-001058	1N9W8	Filtration plant	South Fork of Divide Creek	Rapid sand filtration plant (alum, lime, ammonia, chlorine added)	None
Bozeman	18,670	26,000	Pending	2S6E17	Facultative lagoon	Unnamed tributary to Rocky Creek	Three cell system with estimated total surface area of six acres. Serves homes in Hillcrest area (120 to 150 lots, 40 to 50% developed). Two cells not in use. Discharge to adjacent coulee is rare.	None

Date Sampled	Average Daily Flow (MGD)	Type of Discharge	BOD5 mg/l	Fecal Coliforms /100 ml	Total Coliforms /100 ml	Chlorine Residual	Remarks
Facility inspected 6/20/74 and 9/9/74		Irregular				Chlorination not provided	Surface water supply with moderate turbidity in spring. Basin manually cleaned as required.
Facility inspected May 19-20, 1975		Irregular					No discharge reported for period ending 7/1/74. Report for period ending 7/1/75 due 8/28/75. Facility provides only a portion of Butte's water supply. See Upper Clark Fork River plan for remainder.
6/20/74, 9/9/74 (no discharge either date)	0	Intermittent					

1) Not measured
2) Parameters listed may not be complete for each sample
3) Estimate
(4) Population data from 1970 census and from Comprehensive Area-Wide Sewer and Water Plan, 1970 (by county) by Mueller and Wirth

TABLE 8. INDUSTRIAL DISCHARGES IN THE UPPER MISSOURI TRIBUTARIES BASIN

Facility (MPDES[1] Permit No.)	Location	Parameter	INITIAL Daily Maximum kg/day	INITIAL Daily Maximum (lbs/day)	INITIAL Instantaneous Discharge Rate kg/day	INITIAL Instantaneous Discharge Rate (lbs/day)	FINAL (effective July 1, 1977) Daily Maximum kg/day	FINAL Daily Maximum (lbs/day)	FINAL Instantaneous Discharge Rate kg/day	FINAL Instantaneous Discharge Rate (lbs/day)
Ennis National Fish Hatchery, Ennis, MT (MT-0000523)	7S 2W 24A	BOD_5[2]	1,200	(2,800)	1,905	(4,200)	79	(174)	118	(261)
		TSS[3]	2,946	(6,500)	4,422	(9,750	95	(210)	143	(315)
Fish Cultural Development Center, Bozeman, MT (MT-)	1S 6E 34C	Permit not issued (8/20/74)								

Facility (MPDES[1] Permit No.)	Location	Parameter	Concentration - mg/l 30-Consecutive Day Period[4]	Concentration - mg/l 7-Consecutive Day Period[5]	Remarks
The Montana Power Company, Madison Dam (MT-0023167)	4S 1E 17BCD	BOD_5	30	45	pH must not exceed 9.0 S.U. or fall below 6.0 S.U., monitored quarterly. Chlorine residual $\leq$ 0.5 mg/l, monitored bi-monthly. No discharge of floating solids or visible foam in other than trace amounts.
		TSS	30	45	
		Fecal Coliforms/100 ml[6]			

Facility (MPDES(1) Permit No.)	Location	Parameter	Concentration - mg/l 30-Consecutive Day Period(4)	7-Consecutive Day Period(5)	Remarks
Gemco International Inc., Basin, MT (MT-0023370	6N 5W 18D	TSS	N/A	30	$6.0 \leq pH \leq 9.0$ S.U., monitored quarterly. No discharge of floating solids or visible foam in other than trace amounts Flow shall not exceed 0.75 mgd.
		Turbidity (JTU)	N/A	50	
		Total Copper	N/A	0.3	
		Total Zinc	N/A	1.0	
		Total Lead	N/A	0.1	
		Temperature	N/A	N/A	
		Manganese	N/A	N/A	

(1) Montana Pollutant Discharge Elimination System.

(2) Five-day biochemical oxygen demand.

(3) Total suspended solids.

(4) For compliance purposes, this limitation shall be determined by the arithmetic mean of a minimum of three (3) consecutive samples taken on separate weeks in a 30-day period [minimum total of three (3) samples]; not applicable to fecal coliforms - see footnote (6).

(5) For compliance purposes, this limitation shall be determined by the arithmetic mean of a minimum of three (3) consecutive samples taken on separate days in a 7-day period [minimum total of three (3) samples]; not applicable to fecal coliforms - see footnote (6).

(6) For compliance purposes, average for fecal coliforms shall be determined by the geometric mean of a minimum of three (3) consecutive grab samples taken during separate weeks in a 30-day period for the 30-day average, and during separate days in a 7-day period for the 7-day average [minimum total of three (3) samples].

AGRICULTURAL DISCHARGES

Nine waste discharge permit applications for agricultural operations within the basin have been received (Table 9 and Section IX). Six of these are for confined livestock feeding operations; the remaining three are for return flows from irrigated lands. There should be no regular discharge from any of the operations. Other agricultural wastes present in the Upper Missouri tributaries basin include runoff from range and cultivated lands and from land treated with pesticides and fertilizers (Section VI, Non-Point Pollution Sources).

TABLE 9. AGRICULTURAL DISCHARGE PERMITS IN THE UPPER MISSOURI TRIBUTARIES BASIN

Name of Facility	Discharge Permit No.	Date Issued	Location	Description
Richard Batchelder Confined Swine Operation	F-1-H(1)	10-31-72	2N 2E 34AB (Gallatin R. drainage)	Mr. Batchelder operates a total confinement swine operation having capacity for approximately 1,000 head. The animals are held in two buildings constructed over concrete pits. Waste material drops through the slatted floor and is contained in the concrete pits below. This waste material is removed periodically by a liquid manure tank wagon and disposed of on approximately 200 acres of adjacent agricultural land. There should be no discharge from this facility to state waters.
Eugene Horton Confined Swine Operation	F-6-H(1)	5-23-74	3N 5E 32C (Gallatin R. drainage)	Mr. Horton operates a total confinement swine operation having capacity for approximately 570 head. These animals are held in one building. Waste material drops through slatted floors into concrete pits beneath the buildings. This pit provides capacity to store approximately 175 days waste production. In addition, an emergency overflow pond has been constructed to further reduce the possibility of a discharge. The waste material is periodically removed by a liquid manure tank wagon and disposed of on approximately 400 acres of adjacent agricultural land. There should be no discharge from this facility to state waters.

(1) Permit issued under Montana state permit system, superseded by MPDES.

Name of Facility	Discharge Permit No.	Date Issued	Location	Description
Russell Westlake Confined Swine Operation	MT-0029007	6-18-74	1S 5E 13AD (Gallatin R. drainage)	Mr. Westlake operates a confined swine facility having capacity for approximately 1,000 head. The livestock are contained primarily within two open-front, concrete-floored buildings. Waste material which accumulates on the feeding floor is scraped into concrete pits located adjacent to the feeding floor. Runoff due to precipitation on the feeding floor also is contained in these pits. The waste material is removed and disposed of on 180 acres of agricultural land. There should be no discharge of waste material from this facility to state waters.
Walker Ranches	F-22-H(1)	9-13-73	1S 6E 7CB (Gallatin R. drainage)	Mr. Walker operates a total confinement swine operation having capacity for approximately 85 head. The animals are held within buildings; the waste material produced drops through slatted floors into concrete manure pits below. Excess waste material is discharged to another concrete manure tank. Waste material is removed in a liquid manure tank wagon and disposed of on approximately 1,400 acres of agricultural land. There should be no discharge of waste material to state waters from this facility.

(1) Permit issued under Montana state permit system, superseded by MPDES.

Name of Facility	Discharge Permit No.	Date Issued	Location	Description
Virgil Smith and Son Feedlot	MT-0023400	Pending	5S 6W 7 (Beaverhead R. drainage)	This animal confinement facility has capacity for approximately 2,000 beef animals. The feeding area encompasses approximately five acres. Topography of the area is relatively flat, and runoff from the confinement facility will not reach state waters, according to the applicant. Additional information regarding a waste management program will be obtained at the time an on-site evaluation is made prior to the issuance of a permit. It will be necessary to control, through natural means or constructed control facilities, the runoff from the feeding area which can be expected following a 10-year, 24-hour rainfall event.

WASTE DISCHARGE PERMIT APPLICATIONS FOR IRRIGATION DISTRICTS

Applicant Name	Location	Discharge Permit No.	Date Issued	Watershed	Number of Irrigated Acres	Estimated Return Flow Acre-Feet per Year
East Bench Irrigation District	Dillon	MT-0022934	Pending	Beaverhead River downstream of Clark Canyon Dam	22,722	unknown

Applicant Name	Location	Discharge Permit No.	Date Issued	Watershed	Number of Irrigated Acres	Estimated Return Flow Acre-Feet per Year
High Line Canal Company	Bozeman	MT-0022845	Pending	West Gallatin River downstream of the Gallatin Canyon (approximately ten miles south of Gallatin Gateway, MT)	10,000	unknown
Low Line Canal Company	Bozeman	MT-0022977	Pending	West Gallatin River downstream of the Gallatin Canyon (approximately ten miles south of Gallatin Gateway, MT)	10,000	unknown

MINING ACTIVITY

Mining in the Upper Missouri tributaries basin is over 100 years old and generally dormant. However, increasing metals prices have spurred renewed interest, so water pollution problems are expected to increase as mining increases. Mining activities in Montana are regulated by the Montana Department of State Lands. Land reclamation and compliance with Montana's water pollution laws are addressed in regulations of the Department of State Lands.

Mining activity has been quite extensive in the Beaverhead, Big Hole, Boulder, Jefferson, and Ruby River drainages but slight in the Gallatin, Red Rock, and Madison River drainages. Extensive surveys of the Jefferson River drainage by the Montana Bureau of Mines and Geology (Miller, et.al., March 1974) and the Montana Department of Health and Environmental Sciences.

1. Mining appears to have had little effect on water quality in the Big Hole, Ruby, Beaverhead, and Jefferson River (excluding the Boulder River) drainages. Toxic metals(1) released by mining appears insignificant. However, many small tributaries of these streams have been physically altered by placering and the deposition of tailings and overburden into or on the banks of these tributaries. These physical alterations probably have resulted in channel instabilities; however, the attributable sediment load may also cause stream temperatures to increase because shade-providing vegetative cover may have been lost.

2. The effects of 100 years of mining activity in the Boulder River drainage near Boulder, Montana, have degraded severely water quality in portions of the watershed. Poor water quality has caused suppression of the fishery and aquatic life, particularly in the Boulder River and its tributaries between Basin and Boulder, Montana. Both toxic metals and metals-bearing sediment enter the Boulder River and some of its tributaries in this reach of the river. Principal pollution sources are the Crystal and Comet mines (Section VIII).

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(1) Toxic metals are those metals which have been shown to have adverse biological effects in only trace concentrations. Toxic metals measured routinely in the Upper Missouri tributaries basin were cadmium, zinc, copper, and lead. Arsenic, a semi-metal, was measured routinely and is considered a metal for purposes of discussion.

Sand, gravel, and rock have been mined for construction purposes in all counties of the basin, but resulting water quality degradations are believed slight and only of a very local nature. Other non-metallic mining in the basin has been minor and is not considered a water pollution problem.

One waste discharge permit (Table 8) for mining operations in the Upper Missouri tributaries basin has been issued to Gemco International, Inc. No other permits for mining related discharges in the basin have been issued or are contemplated.

NONPOINT SOURCES

Agriculture (including livestock grazing and crop production), logging, mineral exploration, and mining are the major activities in the Upper Missouri tributaries drainage basin. These are also considered the major nonpoint pollution sources in the basin. Erosion of agricultural land, animal wastes (including wildlife), and fertilizers can create nonpoint pollution sources. Siltation, elevated water temperatures, and increases in nutrients are quality problems normally created in surface waters in heavily logged areas. Stream bank disturbance and poorly constructed roads by mining interests have created sedimentation problems. Construction projects and toxic substances from geological formations are also other, but more minor, nonpoint sources. Several nonpoint sources have been identified or are indicated (Table 10).

TABLE 10. STUDY NEEDS FOR KNOWN AND INDICATED NON-POINT POLLUTION SOURCES IN THE UPPER MISSOURI TRIBUTARIES BASIN

Problem Description	Priority for Future Study	Source	Remarks
Arsenic and fluoride levels in Madison River exceed 1962 U. S. Public Health Service limits	None	Thermal areas of Yellowstone National Park are probable sources based on available data.	Madison River would be unsuitable for domestic supply with existing arsenic and fluoride levels.
High toxic metals levels in Boulder River near Boulder, Montana	Moderate	Sources are extensive mining activity in watershed, particularly upstream of Boulder, Montana.	Preliminary study completed (Braico and Botz, December 9, 1974). Present activit level is low.
High sediment loads in Grasshopper Creek downstream of Bannack, Montana; limited salmonid population	Low	Most of the erosion appears to occur in the first four or five miles downstream of Bannack, Montana. Sediment probably due to channel instability due to past placer mining, overgrazing and tailings erosion (minor). Stream lies at bottom of narrow canyon, which has been extensively placered.	Conclusions based on Water Quality Bureau field investigation (July 11, 1973). Poo salmonid population probably due to extensive areas of shifting sand bottom caused by earlier placering.
High sediment yields to Big Sheep Creek via Muddy Creek near Dell, Montana	Low	Erosion occurs between mouth of Muddy Creek and confluence of Wilson and Sourdough creeks. Erosion probably is due to past overgrazing (as evidenced by recent sagebrush spraying) and poor road building practices. Water collected on uphill side of road is discharged through culvert to downhill side as point source where severe erosion is evident.	Conclusions based on Water Quality Bureau field investigation (July 12, 1974). Soi in drainage is almost exclusively fine-grained with little sand and gravel evident.

Problem Description	Priority for Future Study	Source	Remarks
Moderate sediment yields in East Gallatin River	Moderate	Apparent cause is agricultural encroachment of stream bank. Stream flows through area of easily eroded soil.	Conclusions based on study by Stuart, et.al. (1974) and field observations by author (July, 1971).
Moderate sediment loads to stream within the basin from past mining activites	Moderate	Tailings areas, overburden piles, and unstable channel conditions created by dredge mining. Problems are severe in the Boulder River drainage and in Grasshopper Creek (Section VIII). Similar problems are likely in other mining areas in the basin.	Areas which are generally known are discussed in Section VIII; however, available data is not extensive. Data collected in Montana Bureau of Mines and Geology study (March, 1974) was during low water year and was not conclusive.
Moderate sediment loads to the Beaverhead River downstream of Clark Canyon Dam	Moderate	Observations by Peterson (July 8, 1974) indicate hydrographic modifications of the Beaverhead River by Clark Canyon Dam may be a major reason for stream bank caving on the Beaverhead River.	Portions of the Beaverhead River channel between the dam and Barrett's diversion have been riprapped since construction of the dam.
Moderate sediment loads to the Gallatin, Big Hole and Jefferson rivers by man-induced stream channel alterations	Moderate	Stream channel alterations for agricultural purposes are believed common in the basin.	Dunkle (1955) discussed channel changes to the West Gallatin River by agricultural interests. Channel manipulations of the Big Hole River was discussed by Peterson (February 15, 1974).
High sediment yields from Red Rock River drainage upstream of Lima Reservoir	High	Sources are eroding soils in the watershed due to overgrazing and irrigation practices. Sediment is deposited in the streams and lakes of the Red Rock Lakes National Wildlife Refuge.	Conclusions based on personal communication (E. D. Stropps to D. M. Zollman, January 8, 1974).

Problem Description	Priority for Future Study	Source	Remarks
High sediment yields due to various logging activities	Moderate	Poorly constructed roads, creation of unstable land masses and unprotected slopes, skidding and yarding in natural drainages.	Logging activities on Burlington Northern lands in the Hyalite Creek drainage south of Bozeman, Montana, have resulted in a land flow (Montana Department of Health and Environmental Sciences, February 7, 1975). Similar situations likely have occurred in other drainages.

VII. SURFACE WATER RESOURCES

The Upper Missouri tributaries basin contains eight major sub-basins (Figure 1 and Plate I). They are the Red Rock, Beaverhead, Big Hole, Ruby, Madison, Jefferson, Boulder, and Gallatin River drainages. The U. S. Geological Survey has had 86 stream flow gaging stations in the Upper Missouri tributaries basin (Table 11). Fourteen of these remain active.

Stream flows in the Upper Missouri tributaries basin are affected by local weather conditions, geology, reservoirs, and irrigation (Table 12). A major part of flow occurs during spring runoff. However, spring runoff is a function of weather and precipitation and may be quite variable in both time and volume of runoff. March through early July is the most common snow melt period, but warm weather in mid-winter can produce significant short-term increases in stream flows. Peak flows from mountain streams tend to occur from mid-May through early July; whereas, foothill streams may reach peak stream flows in March.

Late spring and summertime flows in the Big Hole, Lower Ruby, Red Rock, Beaverhead, Boulder, Jefferson, and West Gallatin rivers are regulated extensively by irrigation requirements. Flows in the West Gallatin, Boulder, and Jefferson rivers are known to be minimal at times before the entrance of irrigation returns. Portions of many of the small tributary streams in the basin are dewatered in summer for irrigation. Storage of water for irrigation is a major function of Lima, Clark Canyon, Ruby, and numerous smaller reservoirs in the basin.

Major streams of the basin are discussed separately because of varying geological settings and man-related uses, which are important to an understanding of the basin's water quality.

TABLE 11. SUMMARY OF U. S. GEOLOGICAL SURVEY STREAMFLOW GAGING STATION DATA
(Partial Record Stations Not Included)(4)

Station Name	USGS Station No.	Location(1)	Minimum Streamflow (cfs) Instantaneous	Minimum Streamflow (cfs) Daily	7-day, 10-year Low Flow	Average Annual Flow (cfs)	Period of Record
Beaverhead River near Grant, Montana	06015400	9S 10W 32DCB	0	39	not determined	385	1962 -
Beaverhead River at Barretts	06016000	8S 9W 19DC	69	not determined	not determined	416	1907 -
Beaverhead River near Dillon, MT	06018000	6S 8W 22AAB	8.5	not determined	not determined	387	1950 - 1952, 1963 -
Beaverhead River near Twin Bridges, MT	06018500	5S 7W 22DBC	7.0	not determined	not determined	407	1935 -
Ruby River above reservoir near Alder, MT	06019500	7S 4W 31CC	not determined	35	58	172	1938 -

(1) See Appendix C.

Station Name	USGS Station No.	Location[1]	Minimum Streamflow (cfs) Instantaneous	Daily	7-day, 10-year Low Flow	Average Annual Flow (cfs)	Period of Record
Ruby River below reservoir near Alder, MT	06020600	7S 4W 8AD	not determined	19	not determined	222	1962 -
Trail Creek near Wisdom, MT	06024500	2S 17W 16C	1.6	not determined	not determined	85.3	1948 - 1953, 1966 - 1972
Big Hole River near Melrose, MT	06025500	3S 9W 34CDD	49	not determined	123	1,150	1923 -
Birch Creek near Glen, MT	06026000	5S 10W 23DD	0.8	not determined	2.1	29.6	1946 - 1953, 1955 -
Jefferson River near Twin Bridges, MT	06026500	2S 6W 34CD	82	not determined	not determined	2,014	1940 - 1943, 1957 - 1972
Boulder River near Boulder, MT	06033000	5N 4W 3CA	0	0	5.0	121	1929 - 1932, 1934 - 1972
Willow Creek near Harrison, MT	06035000	1S 1W 28BC	1.4	not determined	not determined	39.3	1938 -
Madison River near West Yellowstone, MT	06037500	13S 5E 36C	100	not determined	290	488	1913 - 1917, 1918 - 1921, 1922 -
Madison River below Hebgen Lake near Grayling, MT	06038500	11S 3E 22AA	not determined	5	not determined	984	1909 -

(1) See Appendix C.

Station Name	USGS Station No.	Location[1]	Minimum Streamflow (cfs) Instantaneous	Minimum Streamflow (cfs) Daily	7-day, 10-year Low Flow	Average Annual Flow (cfs)	Period of Record
Madison River near Cameron, MT	06040000	7S 1W 8	not determined	275	not determined	1,432	1951 - 1963, 1968 - 1970
Red Rock River below Lima Reservoir near Monida, MT	6-0125	13S 6W 32C	0	not determined	not determined	143	[2] 1911 - 1969
Jefferson River at Sappington, MT	6-0345	1N 1W 29D	84	not determined	not determined	2,125	[2] 1895 - 1969
Whitetail Creek near Whitehall, MT	6-0290	3N 5W 10D	not determined	0.2	not determined	not determined	[2] 1949 - 1968
Red Rock River at Kennedy Ranch near Lakeview, MT	6-0110	14S 4 W 2	1.5	not determined	not determined	not determined	1936 - 1967
Red Rock River near Dell, MT	6-0140	12S 9W 20B	0	not determined	not determined	not determined	1942 - 1967
Taylor Creek near Grayling, MT	6-0430	9S 4E 11BB	7.4	not determined	not determined	97.9	[2] 1946 - 1967
Blacktail Deer Creek near Dillon, MT	6-0175	9S 8W 14C	5.6	not determined	12.0	54.0	[2] 1946 - 1966

(1) See Appendix C.
(2) Data not continuous for period shown.

Station Name	USGS Station No.	Location[1]	Minimum Streamflow (cfs) Instantaneous	Daily	7-day, 10-year Low Flow	Average Annual Flow (cfs)	Period of Record
Willow Creek near Glen, MT	6-0258	4S 10W 34A	not determined	3	not determined	not determined	1962 - 1966
West Fork Madison River near Cameron, MT	6-0392	11S 1E 10D	not determined	30	not determined	not determined	[2] 1959 - 1966
Ruby River near Twin Bridges, MT	6-230	4S 6W 10BA	not determined	1.8	not determined	196	[2] 1940 - 1965
Grasshopper Creek near Dillon, MT	6-0155	8S 10W 26BC	0	not determined	not determined	51.6	[2] 1921 - 1961
Ruby River at Laurin, MT	6-0215	5S 4W 32DC	not determined	8	not determined	77.5	1946 - 1961
Madison River at Kirby Ranch near Cameron, MT	6-0388	11S 1E 10DA	not determined	280	not determined	not determined	1959 - 1963
East Gallatin River at Bozeman, MT	6-0480	1S 6E 31	12	not determined	18.0	84.7	1939 - 1961
Ruby River near Alder, MT	6-0210	6S 4W 28AB	not determined	0.3	not determined	88.1	[2] 1929 - 1961
Sheep Creek below Muddy Creek near Dell, MT	135	13S 10W C	26	not determined	not determined	63.7	[2] 1936 - 1960

(1) See Appendix C.
(2) Data not continuous for period shown.

Station Name	USGS Station No.	Location[1]	Minimum Streamflow (cfs) Instantaneous	Daily	7-day, 10-year Low Flow	Average Annual Flow (cfs)	Period of Record
Red Rock River at Red Rock, MT	145	10S 10W 33C	not determined	4.0	not determined	not determined	1890, 1950 - 1952
Horse Prairie Creek near Grant, MT	150	9S 13W 32BA	not determined	12.0	not determined	109	1946 - 1953
Ruby River above Warm Springs Creek near Alder, MT	190	10S 3W 3B	6.8	not determined	not determined	not determined	1948 - 1953
Ruby River below Ramshorn Creek near Sheridan, MT	220	5S 5W 10C	52	not determined	not determined	198	1946 - 1953
Big Hole River near Jackson, MT	235	7S 15W 9AA	not determined	5	not determined	not determined	1948 - 1953
Willow Creek diversions to Birch Creek near Glen, MT	257	5S 10W 5BB	not determined	not determined	not determined	not determined	[2] 1946 - 1960
Boulder River	305	6N 7W 20C	not determined	0.5	not determined	11.7	1946 - 1953
Norwegian Creek near Harrison, MT	355	2S 1W 10C	0.8	not determined	not determined	6.66	[2] 1938 - 1951

(1) See Appendix C.
(2) Data not continuous for period shown.

Station Name	USGS Station No.	Location(1)	Minimum Streamflow (cfs) Instantaneous	Daily	7-day, 10-year Low Flow	Average Annual Flow (cfs)	Period of Record
Willow Creek near Willow Creek, MT	365	1S 1E 18BC	0.3	not determined	not determined	51.0	(2) 1919 - 1956
South Cottonwood Creek near Gallatin Gateway, MT	445	3S 5E 34A	9.2	not determined	not determined	not determined	1951 - 1953
Gallatin River at Axtell Bridge near Gallatin Gateway, MT	450	2S 4E 35BC	not determined	220	not determined	not determined	(2) 1950 - 1953
Gallatin River near Belgrade, MT	455	1S 4E 22BB	27	not determined	not determined	not determined	1950 - 1953
Gallatin River near Manhattan, MT	460	1N 4E 19AC	4.8	not determined	not determined	not determined	(2) 1950 - 1953
Bear Canyon Cr. near Bozeman, MT	470	2S 6E 36B	not determined	1.1	not determined	not determined	1951 - 1953
Bozeman Creek near Bozeman, MT	475	3S 6E 17CB	not determined	5	not determined	not determined	1951 - 1953
East Gallatin River near Bozeman, MT	465	2S 6E 24D	7.9	not determined	not determined	not determined	1951 - 1953

(1) See Appendix C.
(2) Data not continuous for period shown.

Station Name	USGS Station No.	Location[1]	Minimum Streamflow (cfs) Instantaneous	Daily	7-day, 10-year Low Flow	Average Annual Flow (cfs)	Period of Record
Middle Cottonwood Creek near Bozeman, MT	490	1S 6E 9C	not determined	not determined	not determined	not determined	1951 - 1953
Ross Creek near Belgrade, MT	505	1N 6E 16B	not determined	9.2	not determined	not determined	1951 - 1953
Reese Creek near Belgrade, MT	510	1N 5E 10A	4.0	not determined	not determined	not determined	1951 - 1953
Dry Creek at Andrus Rnach near Manhattan, MT	515	2N 4E 23D	not determined	not determined	not determined	not determined	1951
Dry Creek at Brownell Ranch near Manhattan, MT	520	2N 4E 26C	4.7	not determined	not determined	not determined	1951
Red Rock River near Lakeview, MT	1	14S 2W 6BD	0	not determined	not determined	not determined	1933 - 1937
Red Rock River at Metzel Ford near Monida, MT	2	13S 3W 34BB	2.7	not determined	not determined	not determined	1925 - 1929
Red Rock River above Lima Reservoir near Monida, MT	4	14S 4W 8A	0.4	not determined	not determined	not determined	[2] 1911 - 1930

(1) See Appendix C.
(2) Data not continuous for period shown.

Station Name	USGS Station No.	Location[1]	Minimum Streamflow (cfs) Instantaneous	Daily	7-day, 10-year Low Flow	Average Annual Flow (cfs)	Period of Record
Red Rock River at Lima, MT	7	14S 8W 3C	14	not determined	not determined	not determined	1907 - 1911
Rattlesnake Creek near Dillon, MT	14	6S 11W 15A	0.6	not determined	not determined	not determined	1946 - 1949
Ruby River at dam site near Alder, MT	19	7S 4W 8D	39	not determined	not determined	not determined	1911 - 1914, 1935 - 1937
Ruby River near Sheridan, MT	24	5S 5W 5B	not determined	56	not determined	not determined	1946 - 1950
Miner Creek near Jackson, MT	27	6S 16W 3C	not determined	3	not determined	not determined	1948 - 1950
Big Hole River near Dewey, MT	29	1N 11W 36	not determined	not determined	not determined	not determined	1910 - 1913
Jefferson River near Silverstar, MT	34	2S 6W 23C	50	not determined	not determined	1,714	[2]1910 - 1939
Bell Creek near Waterloo, MT	35	2S 4W 7D	4.6	not determined	not determined	not determined	1941 - 1942
Big Pipestone Creek near Whitehall, MT	36	2N 5W 35B	0.5	not determined	not determined	not determined	1910 - 1911

(1) See Appendix C.
(2) Data not continuous for period shown.

Station Name	USGS Station No.	Location(1)	Minimum Streamflow (cfs) Instantaneous	Daily	7-day 10-year Low Flow	Average Annual Flow (cfs)	Period of Record
Little Pipestone Creek near Whitehall, MT	37	1N 6W 13A	0.5	not determined	not determined	3.4	1935 - 1940
Little Whitetail Creek near Whitehall, MT	39	3N 4W 28CC	0.6	not determined	not determined	not determined	1911
Whitetail Creek at Whitehall, MT	40	2N 4W 34C	0.6	not determined	not determined	not determined	1911
Rock Creek at CCC Camp near Belgrade, MT	42	6N 7W 20C	0	not determined	not determined	not determined	1936
Boulder River at Basin, MT	43	6N 5W 18D	7.6	not determined	not determined	not determined	1921 - 1923
Boulder River near Basin, MT	44	6N 5W 17	0.6	not determined	not determined	not determined	1919 - 1920
Muskrat Creek near Boulder, MT	45	6N 3W 6B	0.8	not determined	not determined	not determined	1912 - 1914
North Fork Little Boulder River near Boulder, MT	47	5N 4W 8C	not determined	not determined	not determined	not determined	1926 - 1927
South Boulder Creek near Jefferson Island, MT	48	2S 3W 18C	2.0	not determined	not determined	not determined	1926 - 1933

(1) See Appendix C.
(2) Data not continuous for period shown.

Station Name	USGS Station No.	Location(1)	Minimum Streamflow (cfs) Instantaneous	Daily	7-day 10-year Low Flow	Average Annual Flow (cfs)	Period of Record
Gibbon River near West Yellowstone, MT	54	(3)Lat.44°39'00" Long.110°47'40"	62.0	not determined	not determined	not determined	1913 - 1916
West Fork Madison River near Lakeview, MT	58	12S 2W 30BB	0	not determined	not determined	not determined	1936
Madison River at Lyon, MT	59	10S 1E 29AA	255	not determined	not determined	not determined	1928 - 1932
Madison River near Norris, MT	62	3S 1E 11BC	850	not determined	not determined	not determined	(2)1890 - 1911
Madison River below Cherry Creek near Norris, MT	63	2S 2E 19D	not determined	not determined	not determined	not determined	1987 - 1906
Madison River near Three Forks, MT	64	1N 2E 20AC	416	not de-	not de-	1,650	1893 - 1950
Gallatin River near Salesville, MT	67	3S 4E 33	not determined	not determined	not determined	958	1895 - 1923

(1) See Appendix C.
(2) Data not continuous for period shown.
(3) Township, range and section data not determined.

Station Name	USGS Station No.	Location[1]	Minimum Streamflow (cfs) Instantaneous	Daily	7-day, 10-year Low Flow	Average Annual Flow (cfs)	Period of Record
Blaine Spring Creek near Cameron, MT	06040010	7S 2W 24AB	not determined	14	not determined	37	1971 - 1972
Madison River below Ennis Lake near McAllister, MT	06041000	4S 1E 17B	not determined	210	not determined	1,726	1901 - 1905, 1906 -
Gallatin River near Gallatin Gateway, MT	06043500	4S 4E 7DDD	117	not determined	200	795	1889 - 1894, 1930 - 1969
Bridger Creek near Bozeman, MT	06048500	1S 6E 34DA	0.9	not determined	2.2	36.6	1945 - 1969, 1971 - 1972
Hyalite Creek at Hyalite Ranger Station near Bozeman, MT	06050000	3S 5E 23DB	not determined	5	10.0	65.7	[2]1895 -
Gallatin River at Logan, MT	06052500	2N 2E 35A	130	not determined	not determined	1,025	[2]1893 -
Beaverhead River at Dillon, MT	06017000	7S 9W 13	not determined	165	not determined	370	1950 - 1952, 1963 - 1971

(1) See Appendix C.
(2) Data not continuous for period shown.

TABLE 12. TYPICAL STREAMFLOW DATA FOR UPPER MISSOURI TRIBUTARIES BASIN, MONTANA
(USGS Water Resources Data for Montana, Part I. Surface Water Records, 1972)

MONTHLY MEAN DISCHARGE (cfs) FOR WATER YEAR OCTOBER 1971 to SEPTEMBER 1972

Month	Beaverhead River near Grant, MT	Beaverhead River near Twin Bridges, MT	Big Hole River near Melrose, MT	Ruby River below Reservoir near Alder, MT	Madison River below Ennis Lake near McAllister, MT	Boulder River near Boulder, MT	Gallatin River at Logan, MT	Jefferson River at Sappington, MT (1)
October	614	880	561	151	2,236	44.3	1,203	1,974
November	468	801	546	72.0	2,404	37.7	1,141	2,037
December	446	719	412	80.4	1,558	29.4	839	1,678
January	330	619	351	86.5	1,614	29.4	721	1,513
February	303	602	338	89.9	1,445	32.0	806	1,505
March	441	799	852	105	1,782	11.7	1,004	1,834
April	763	937	1,243	160	2,762	110	1,042	5,195
May	746	421	4,290	421	2,595	565	2,119	7,298
June	664	324	7,699	715	3,766	613	3,432	4,722
July	749	359	1,501	335	2,044	75.9	918	2,725
August	835	348	650	389	1,645	30.1	503	774
September	465	466	465	276	2,298	28.1	740	964
TOTAL FOR YEAR (Acre-feet)	412,000	439,900	1,142,000	174,200	1,580,000	103,600	873,800	1,944,000
TOTAL FOR AVERAGE YEAR (Acre-feet)	278,900	294,900	833,200	160,800	1,250,000	87,660	742,600	1,540,000

(1) Station discontinued September 1969; data given is for October 1968 to September 1969.

BOULDER RIVER

Headwaters of the Boulder River drain the Boulder Batholith, a mineralized mountain area between Butte and Boulder, Montana. From Boulder, Montana, to its confluence with the Jefferson River near Cardwell, the Boulder River drains a narrow agricultural valley. Large withdrawals are made from the downstream segment to irrigate nearby hayland. A multi-purpose reservoir on the Little Boulder River, a tributary near Boulder, has been proposed by the U. S. Department of Agriculture, Soil Conservation Service. Primary purpose of the project is to augment summer flows in the Boulder River for downstream irrigation (SCS, December, 1974).

BIG HOLE RIVER

Headwaters of the Big Hole River are the many small streams coursing through irrigated haylands and willow bottoms of the broad Big Hole Valley southwest of Butte, Montana (Plate I). Geography restricts irrigation in the river's midsection, but large diversions from Melrose downstream reduce significantly stream flows in the lower river.

BEAVERHEAD RIVER

Origin of the Beaverhead River is the outlet of Clark Canyon Reservoir, a multi-purpose project of the Bureau of Reclamation completed in 1964. Primary purpose of the reservoir is storage of spring runoff waters for irrigation of the land area north and west of Dillon known as the East Bench. Between the dam and Barretts Diversion Dam, a distance of about 15 miles, the river flows through a narrow canyon. From Barretts Diversion Dam to the Ruby River confluence, the Beaverhead River flows through an irrigated agricultural valley with many diversions and returns.

RUBY RIVER

The Ruby River drainage can be divided into two segments. Upstream of Ruby Reservoir, the river is confined to a narrow mountain valley by the Gravelly, Greenhorn, and Snowcrest ranges. Downstream of Ruby Reservoir, the river meanders through the Ruby River Valley before

joining the Beaverhead River near Twin Bridges, Montana. Ruby Reservoir was constructed in 1937 and 1938 as a State (Montana) Water Conservation Board project to furnish irrigation water to 34,000 acres of land in the Ruby and Jefferson River valleys (Water Resources Survey for Madison County, 1954).

GALLATIN RIVER

The Gallatin River is formed by the confluence of its east and west branches northwest of Manhattan, Montana. About five miles downstream of this junction, the Gallatin River passes through a small, rocky canyon at Logan, Montana. The three forks of the Missouri River is reached approximately five miles downstream of Logan. Irrigation returns from haylands along the Lower Madison River are returned to this last segment of the Gallatin River.

The East Gallatin River is formed by the confluence of Rocky and Sourdough (Bozeman) creeks near Bozeman, Montana. From its origin, the East Gallatin meanders northwesterly along the eastern edge of the Gallatin Valley, which is extensively developed for agriculture. The East Gallatin River joins the West Gallatin River northeast of Manhattan, Montana, about 40 miles from its source. Soils along much of the East Gallatin are easily eroded if not protected.

The West Gallatin River rises in Yellowstone Park, flowing northward about 80 miles before reaching the Gallatin Valley near Gallatin Gateway, Montana. Numerous streams draining the Gallatin and Madison ranges are tributary to this reach of the river. Downstream from the canyon, the river is extensively developed for irrigation with zero flows occurring in some sections.

JEFFERSON RIVER

The Jefferson River is formed by the confluence of the Beaverhead and Big Hole rivers about three miles north of Twin Bridges, Montana (Figure 1 and Plate I). Between Twin Bridges and Cardwell, the Jefferson Valley is extensively developed for irrigation, and depletion of flows has been noted (Water Resources Survey, 1954, and Wipperman, June 25, 1974). Major diversions in this reach of the river are the Parrot

and Creeklyn ditches. Irrigation diversions from the Jefferson River between Cardwell and the three forks of the Missouri are not extensive, being somewhat limited by geography.

MADISON RIVER

The Madison River begins in Yellowstone National Park at the confluence of the Gibbons and Fire Hole rivers. Downstream of Yellowstone Park, the Madison is impounded by Hebgen Dam, a Montana Power Company generating facility completed in 1915. Storage capacity of Hebgen Reservoir is 384,840 acre-feet (includes 7,340 acre-feet of dead storage) (USGS Water Resources Data for Montana, 1972). About one mile downstream of Hebgen Dam, the Madison is again impounded by Quake Lake, which was formed by the Madison Earthquake in 1959. Upon leaving Quake Lake and the narrow mountain canyon, the Madison enters a broad mountain valley which extends to Ennis, Montana (Plate I). Ranch land irrigation in this reach of the river is mainly by diversion of tributary streams. At Ennis, the Madison is temporarily impounded by Montana Power Company generating facilities which form Ennis Lake. From the Beartrap Canyon to the three forks of the Missouri River, the Madison River flows through ranch land with some irrigation diversions.

RED ROCK RIVER

The Red Rock River drains an area of about 1,600 square miles in extreme southwestern Montana. Little has been published concerning soils of the drainage, but it is generally believed that much of the area is quite susceptible to erosion. Dominant features of the broad, flat headwaters region is the Red Rock Lakes National Wildlife Refuge, which contains Upper and Lower Red Rock Lakes and Swan Lake. About 13 miles downstream of the refuge is Lima Reservoir, a State Water Conservation Board irrigation project completed in 1902 with a capacity of 84,050 acre-feet (no dead storage) (USGS Water Resources Data for Montana, 1972). The Red Rock River is a slow, meandering, aggraded stream between the refuge and the reservoir (Fish and Wildlife Service, 1956). Downstream of Lima Reservoir, the river meanders through the Red Rock Valley for about 30 miles. Many

ranches occupy this reach of the river, and many diversions are made to irrigate nearby grazing lands.

VIII. WATER QUALITY

This section discusses physical and chemical conditions which describe water quality in the Upper Missouri tributaries basin (water quality standards appear in Appendix B). Data collected for this section is considered baseline, i.e., it quantitatively describes existing water quality at sites selected to be representative of conditions in the basin. However, this data is also subject to a number of constraints:

1. The information has not been collected over a long enough period of time to show gradual changes and trends.

2. It has not been collected at frequent enough intervals to detect extreme short-term conditions which may have long-lasting biological effects.

3. Sampling stations were established only on major streams.

4. Biological samples were not collected, so physical, biological, and chemical characteristics cannot be related directly.

These deficiencies were offset partially by using information developed by others (Section III), by conducting field investigations and studies, and by discussing water quality and water quality related subjects with persons and agencies likely to have input.

Water quality has been measured regularly at 72 stations in the Upper Missouri tributaries basin (Table 13). Temperature only was recorded at 47 of these stations. In addition, the U. S. Forest Service has initiated water quality sampling programs to obtain basic physical and chemical data on important tributaries to comply with Public Law 92-500; however, available information is limited. In addition, considerable sediment data has been collected by the Gallatin National Forest personnel (Table 1).

TABLE 13. UPPER MISSOURI TRIBUTARIES WATER QUALITY STATIONS

Station Name (Agency and No.)	Location[1]	Period of Record	Sampling Frequency	[3]Water Quality Parameters
Beaverhead River at Barretts, MT (USGS 0601600)	8S 9W 19DC	1949-1951, 1965-	Monthly	Dissolved: SiO_2, Fe, Ca, Mg, Na, K, SO_4, Cl, F, $NO_2 + NO_3$, PO_4. Specific conductance, alkalinity, temperature, flow, pH.
Beaverhead River near Twin Bridges, MT (USGS 06018500)	5S 7W 22DBC	1949-1951, 1962-	Monthly	Dissolved: SiO_2, Fe, Ca, Mg, Na, K, SO_4, Cl, Fe, $NO_2 + NO_3$, PO_4. Specific conductance, alkalinity, temperature, flow, pH.
Jefferson River near Twin Bridges, MT (USGS 06026500)	2S 6W 34CD	[2]1957-	Monthly	Dissolved: SiO_2, Fe, Ca, Mg, Na, K, SO_4, Cl, F, $NO_2 + NO_3$, PO_4. Specific conductance, alkalinity, temperature, flow, pH.
Madison River below Ennis Lake near McAllister, MT (USGS 06041000)	4S 1E 17B	1972-	Monthly	Dissolved: Ca, Mg, Na, SO_4, Cl, F, $NO_2 + NO_3$, NH_3 - N, PO_4, P, O_2. Flow, total N, total Kjeldahl - N, total P, BOD_5, temperature, specific conductance, alkalinity, total coliforms, fecal coliforms.
Willow Creek near Glen, MT (USGS 6-258)	4S 10W 34A	1962-1965	Monthly	Flow, SiO_2, Fe, Ca, Mg, Na, K, HCO_3, CO_3, SO_4, Cl, F, NO_3, B, specific conductance, pH, color. Suspended sediment 1964 through 1965.
Big Hole River at Reichle Damsite (Fish and Game)			Thermograph	Temperature
Big Hole River near Twin Bridges, MT (Fish and Game)			Thermograph	Temperature

(1) See Appendix C.
(2) Period of record not continuous.
(3) Analysis indicated may not be complete for each sample collected.

Station Name (Agency and No.	Location[1]	Period of Record	Sampling Frequency	[3] Water Quality Parameters
Big Hole River near Melrose, MT (USGS 6-255)	3S 9W 34CDD	[2] 1956-1964	Biweekly	Flow, SiO_2, Fe, Ca, Mg, Na, K, HCO_3, CO_3, SO_4, Cl, F, NO_3, B, specific conductance, pH, color, suspended sediment, temperature.
Madison River at Kirby Ranch near Cameron, MT (USGS 6-388)	11S 1E 10DA	1959-1963	Twice per week	Flow, suspended sediment
Birch Creek near Glen, MT (USGS 6-260)	5S 10W 23DD	1958-1962	Monthly	Flow, SiO_2, Fe, Ca, Mg, Na, K, HCO_3, CO_3, SO_4, Cl, F, NO_3, B, specific conductance, pH, color, suspended sediment.
Gallatin River at Logan, MT (USGS)	2N 2E 35A	1956-1957	Monthly	Flow, SiO_2, Fe, Ca, Mg, Na, K, HCO_3, SO_4, Cl, F, NO_3, B, temperature, specific conductance, pH, color.
Gallatin River at Williams Bridge near Gallatin Gateway, MT (USGS)	3S 4E 28D	1956-1957	Monthly	Flow, SiO_2, Fe, Ca, Mg, Na, K, HCO_3, SO_4, Cl, F, NO_3, B, specific conductance, pH, color, temperature.
Red Rock River at Kennedy Ranch near Lakeview, MT (USGS 6-0110)	14S 4W 2	1949-1965	Three times per week	Temperature
Red Rock River below Lima Reservoir near Monida, MT (USGS 6-0125)	13S 6W 32C	1950-1965	At time of discharge measurement	Temperature
Sheep Creek below Muddy Creek near Dell, MT (USGS 6-0135)	13S 10W 35C	1949-1953, 1959-1965	At time of discharge measurement	Temperature

(1) See Appendix C.
(2) Period of record not continuous.
(3) Analysis indicated may not be complete for each sample collected.

Station Name (Agency and No.)	Location (1)	Period of Record	Sampling Frequency (3)	Water Quality Parameters
Red Rock River near Dell, MT (USGS 6-0140)	12S 9W 20B	1949-1965	At time of discharge measurement	Temperature
Red Rock River near Red Rock, MT (USGS 6-0145)	10S 10W 34C	1950-1952	At time of discharge measurement	Temperature
Horse Prairie Creek near Grant, MT (USGS 6-0150)	9S 13W 32BA	1949-1953	At time of discharge measurement	Temperature
Horse Prairie Creek below Medicine Lodge Creek near Grant, MT (F & G) (2)	10S 11W 10	1963-1964	Thermograph	Temperature
Beaverhead River near Armstead, MT (F & G)	9S 10W 32DCB	1962-1965	At time of discharge measurement; thermograph	Temperature
Grasshopper Creek near Dillon, MT (USGS 6-0155)	8S 10W 26BC	1949-1953, 1955-1965	At time of discharge measurement	Temperature
Beaverhead River at Barrett, MT (USGS 6-0160)	8S 9W 19D	1949-1965	At time of discharge measurement	Temperature
Blacktail Deer Creek near Dillon, MT (USGS 6-0175)	9S 8W 14D	1949-1953, 1955-1965	At time of discharge measurement	Temperature
Ruby River above Warm Springs Creek near Alder, MT (USGS 6-0190)	10S 3W 3B	1949-1953	At time of discharge measurement	Temperature

(1) See Appendix C.
(2) Montana Department of Fish and Game.
(3) Analysis indicated may not be complete for each sample collected.

Station Name (Agency and No.)	Location[1]	Period of Record	Sampling Frequency	[2] Water Quality Parameters
Ruby River above reservoir near Alder, MT (USGS 6-0195)	7S 4W 31CCC	1949-1965	At time of discharge measurement	Temperature
Ruby River near Alder, MT (USGS 6-0210)	6S 4W 28AB	1949-1961	At time of discharge measurement	Temperature
Ruby River at Laurin, MT (USGS 6-0215)	5S 4W 32DC	1946-1961	At time of discharge measurement	Temperature
Ruby River near Twin Bridges, MT (USGS 6-0230)	4S 6W 10BA	1949-1965	At time of discharge measurement	Temperature
Big Hole River near Jackson, MT (USGS 6-0235)	7S 15W 9BB	1949-1953	At time of discharge measurement	Temperature
Miner Creek near Jackson, MT (USGS 6-0240)	6S 16W 3C	1949-1953	At time of discharge measurement	Temperature
Trail Creek near Wisdom, MT (USGS 6-0245)	2S 17W 16C	1949-1953	At time of discharge measurement	Temperature
Big Hole River near Melrose, MT (USGS 6-0255)	3S 9W 34CDD	1949-1965	At time of discharge measurement	Temperature
Willow Creek near Glen, MT (USGS 6-0258)	4S 10W 34A	1962-1965	At time of discharge measurement	Temperature
Birch Creek near Glen, MT (USGS 6-0260)	5S 10W 23DD	1949-1953, 1955-1965	At time of discharge measurement	Temperature

(1) See Appendix C.
(2) Analysis indicated may not be complete for each sample collected.

Station Name (Agency and No.)	Location[1]	Period of Record	Sampling Frequency	[3] Water Quality Parameters
Jefferson River near Silverstar, MT (USGS 6-0270)	2S 6W 23C	1963	Thermograph	Temperature
Whitetail Creek near Whitehall, MT (USGS 6-0290)	3N 5W 10C	[2] 1949-1965	At time of discharge measurement	Temperature
Jefferson River at Cardwell, MT (F & G)	1N 3W 10AD	1963	Thermograph	Temperature
Boulder River above Rock Creek near Basin, MT (USGS 6-0305)	6N 7W 20C	1949-1953, 1955-1957	At time of discharge measurement	Temperature
Boulder River near Boulder, MT (USGS 6-0330)	5N 4W 3CA	1949-1965	At time of discharge measurement	Temperature
Jefferson River at Sappington, MT (USGS 6-0345)	1N 1W 29D	1949-1965	At time of discharge measurement	Temperature
Willow Creek near Harrison, MT (USGS 6-0350)	1S 1W 28BC	1949-1965	At time of discharge measurement	Temperature
Willow Creek near Willow Creek, MT (USGS 6-0365)	1S 1E 18BC	1949-1953, 1955-1956	At time of discharge measurement	Temperature
Madison River near West Yellowstone, MT (USGS 6-0375)	13S 5E 36C	1949-1965	At time of discharge measurement	Temperature

(1) See Appendix C.
(2) Period of record not continuous.
(3) Analysis indicated may not be complete for each sample collected.

Station Name (Agency and No.)	Location[1]	Period of Record	Sampling Frequency[3]	Water Quality Parameters
Madison River above Hebgen Lake near West Yellowstone, MT (F & G)	13S 5E 10DC	1961-1963	Thermograph	Temperature
Hebgen Lake near West Yellowstone, MT (Danny Martin) 6-0380	12S 4E 5C	Summer 1964, 1965	Weekly	Temperature
Madison R. bel Hebgen Lk nr Grayling, MT (F&G) 6-0385	11S 3E 22A	1949-1965	At time of discharge measurement	Temperature
Quake Lake, West Yellowstone, MT (Montana State University)	11S 2E 36	Summer 1965	Weekly	Temperature
Madison River at Kirby Ranch near Cameron, MT (USGS 6-0388)	11S 1E 10CA	1959-1963	At time of discharge measurement	Temperature
Madison River near Cameron, MT (USGS 6-0400)	7S 1W 8	[2] 1951-1963	At time of discharge measurement	Temperature
Madison River at Ennis, MT	6S 1W 4A	1961-1962	Thermograph	Temperature
Madison River below Ennis Lake near McAllister, MT (USGS 6-0410)	4S 1E 17B	1949-1965	At time of discharge measurement; Thermograph	Temperature

(1) See Appendix C.
(2) Period of record not continuous.
(3) Analysis indicated may not be complete for each sample collected.

Station Name (Agency and No.)	Location (1)	Period of Record	Sampling Frequency (2)	Water Quality Parameters
Madison River at Three Forks, MT (F & G)	2N 2E 30	1962	Thermograph	Temperature
Taylor Creek near Grayling, MT (USGS 6-0430)	9S 4E 11BB	1949-1953, 1955-1957	At time of discharge measurement	Temperature
Gallatin River near Gallatin Gateway, MT (USGS 6-0435)	4S 4E 7DD	1949-1965	At time of discharge measurement	Temperature
East Gallatin River at Bozeman, MT (USGS 6-0480)	1S 6E 31	1949-1961	At time of discharge measurement	Temperature
Bridger Creek near Bozeman, MT (USGS 6-0485)	1S 6E 34DA	1949-1965	At time of discharge measurement	Temperature
Hyalite Creek at Hyalite Ranger Station near Bozeman, MT (USGS 6-0500)	3S 5E 23DB	1949-1965	At time of discharge measurement	Temperature
Gallatin River at Logan, MT (USGS 6-0525)	2N 2E 35A	1949-1965	At time of discharge measurement	Temperature
Red Rock River near Dell, MT (WQB) (3)	12S 9W 20B	1972-1973	Monthly	(4) Ca, Mg, Na, HCO_3, Cl, SO_4, NO_3, F, PO_4, pH, specific conductance, D.O., turbidity, BOD_5, As, Cu, Pb, An, Fe, Cd, total coliforms, temperature, flow.

(1) See Appendix C.
(2) Analysis indicated may not be complete for each sample collected.
(3) Montana Department of Health and Environmental Sciences, Environmental Sciences Division, Water Quality Bureau.
(4) Water Quality Bureau analyses for arsenic, zinc, iron, lead, and copper are total recoverable unless otherwise indicated.

Station Name (Agency and No.)	Location[1]	Period of Record	Sampling Frequency	[2] Water Quality Parameters
Beaverhead River near Grant, MT (WQB)	9S 10W 32DCB	1972-1973	Monthly	Ca, Mg, Na, HCO_3, Cl, SO_4, NO_3, F, PO_4, pH, specific conductance, D.O., turbidity, BOD_5, As, Cu, Pb, Zn, Fe, Cd, total coliforms, temperature, flow.
Big Hole River near Melrose, MT (WQB)	3S 9W 34CDD	1972-1973	Monthly	Ca, Mg, Na, HCO_3, Cl, SO_4, NO_3, F, PO_4, pH, specific conductance, D.O., turbidity, BOD_5, As, Cu, Pb, Zn, Fe, Cd, total coliforms, temperature, flow.
Ruby River above reservoir near Alder, MT (WQB)	7S 4W 31CC	1972-1973	Monthly	Ca, Mg, Na, HCO_3, Cl, SO_4, NO_3, F, PO_4, pH, specific conductance, D.O., turbidity, BOD_5, As, Cu, Pb, Zn, Fe, Cd, total coliforms, temperature, flow.
Ruby River below reservoir near Alder, MT (WQB)	7S 4W 8AD	1972-1973	Monthly	Ca, Mg, Na, HCO_3, Cl, SO_4, NO_3, F, PO_4, pH, specific conductance, D.O., turbidity, BOD_5, As, Cu, Pb, Zn, Fe, Cd, total coliforms, temperature, flow.
Ruby River near Twin Bridges, MT (WQB)	4S 6W 10BA	1972-1973	Monthly	Ca, Mg, Na, HCO_3, Cl, SO_4, NO_3, F, PO_4, pH, specific conductance, D.O., turbidity, BOD_5, As, Cu, Pb, Zn, Fe, Cd, total coliforms, temperature, flow.
Jefferson River at Sappington, MT (WQB)	1N 1W 29D	1972-1973	Monthly	Ca, Mg, Na, HCO_3, Cl, SO_4, NO_3, F, PO_4, pH, specific conductance, D.O., turbidity, BOD_5, As, Cu, Pb, Zn, Fe, Cd, total coliforms, temperature, flow.
Madison River at Kirby Ranch near Cameron, MT (WQB)	11S 1E 10DA	1972-1973	Monthly	Ca, Mg, Na, HCO_3, Cl, SO_4, NO_3, F, PO_4, pH, specific conductance, D.O., turbidity, BOD_5, As, Cu, Pb, Zn, Fe, Cd, total coliforms, temperature, flow.
Madison River near Cameron, MT (WQB)	7S 1W 8 DCC	1972-1973	Monthly	Ca, Mg, Na, HCO_3, Cl, SO_4, NO_3, F, PO_4, pH, specific conductance, D.O., turbidity, BOD_5, As, Cu, Pb, Zn, Fe, Cd, total coliforms, temperature, flow.
Madison River below Ennis Lake near McAllister, MT (WQB)	4S 1E 17B	1972	Monthly	Ca, Mg, Na, HCO_3, Cl, SO_4, NO_3, F, PO_4, pH, specific conductance, D.O., turbidity, BOD_5, total coliforms, temperature, As, Cu, Pb, Zn, Fe, Cd, flow.

(1) See Appendix C.
(2) Analysis indicated may not be complete for each sample collected.

Station Name (Agency No.)	Location (1)	Period of Record	Sampling Frequency	(2) Water Quality Parameters
Gallatin River at Logan, MT (WQB)	2N 2E 35A	1972-1973	Monthly	Ca, Mg, Na, HCO_3, Cl, SO_4, NO_3, F, PO_4, pH, specific conductance, turbidity, BOD_5, total and fecal coliforms, temperature, As, Cu, Pb, Zn, Fe, Cd, flow.
Bridger Creek near Federal Fish Hatchery near Bozeman, MT (WQB)	1S 6E 34CBB	1973	Quarterly	Ca, Mg, Na, HCO_3, Cl, SO_4, NO_3, F, PO_4, pH, specific conductance, turbidity, BOD_5, total and fecal coliforms, temperature, As, Cu, Pb, Zn, Fe, Cd, flow.
Boulder River near Boulder, MT (WQB)	5N 4W 3CA	1972-1973	Monthly	Ca, Mg, Na, HCO_3, Cl, SO_4, NO_3, F, PO_4, pH, specific conductance, turbidity, BOD5, total and fecal coliforms, temperature, As, Cu, Pb, Zn, Fe, Cd, flow.
Boulder River at Highway 10 Bridge near Cardwell, MT (WQB)	1N 3W 2BAC	1972-1973	Monthly	Ca, Mg, Na, HCO_3, Cl, SO_4, NO_3, F, PO_4, pH, specific conductance, turbidity, BOD5, total and fecal coliforms, temperature, As, Cu, Pb, Zn, Fe, Cd, flow.
Little Boulder River near Boulder, MT (SCS)	5N 4W 9ABC	6/73-10/73	Bi-monthly	Ca, Mg, Na, HCO_3, Cl, SO_4, NO_3, PO_4, pH, temperature, specific conductance, turbidity. Total recoverable: Fe, An, Cd, Cu, Pb, Hg.
Madison R. below Ennis Lk nr McAllister, MT (WQB)	4S 1E 17B	2/72-7/72	Monthly	Ca, Mg, Na, HCO_3, Cl, SO_4, F, PO_4, pH, specific conductance, turbidity, BOD_5, total coliforms, temperature, As, Cu, Pb, Zn, Fe, Cd, flow.
Madison R below Ennis Lk, nr McAllister, MT (USGS 06041000)	4S 1E 17B	7/72-9/73	Monthly	Ca, Mg, Na, SO_4, Cl, F, HCO_3, temperature, specific conductance, pH, dissolved oxygen, total and fecal coliforms, NO_2 + NO_3 (dissolved and total), total-N, total Kjeldahl-N, PO_4 (total and dissolved), total-P, BOD_5.

(1) See Appendix C.
(2) Analysis indicated may not be complete for each sample collected.

Station Name (Agency No.)	Location (1)	Period of Record	Sampling Frequency	(2) Water Quality Parameters
Madison R near Three Forks, MT (WQB)	1N 2E 20AC	1972-1973	Monthly	Ca, Mg, Na, HCO_3, Cl, SO_4, F, PO_4, pH, specific conductance, turbidity, BOD_5, total coliforms, temperature, As, Cu, Pb, Zn, Fe, Cd, flow.
Big Hole R nr Children's Center nr Twin Bridges, MT (F & G)	3S 6W 29A	6/73-8/73	Continuous	temperature
Big Hole R nr Melrose, MT (F & G)	3S 9W 34 CDD	6/73-8/73	Continuous	temperature
Big Hole R at Reichle Dam Site (F & G)	8W 5S 3A	July-Aug. for'71,'72,'73	Continuous	temperature

(1) See Appendix C.
(2) Analysis indicated may not be complete for each sample collected.

The Upper Missouri tributaries basin has been divided into eight segments for discussion purposes. Typical water quality data for streams discussed in this report appear in Table 14. Stream temperatures typically vary from 0° C in winter to the high teens and mid-twenties for small mountain streams and larger rivers, respectively. All samples collected by the Water Quality Bureau (Table 14) were grab samples and were analyzed in the Montana Department of Health and Environmental Sciences chemistry laboratory.

Water quality in the basin is excellent, but several problems are indicated:

1. Salmonid and associated aquatic life in the Boulder River drainage downstream to at least Boulder, Montana, have been affected by toxic metals and sediment from mining activity.

2. Severe erosion occurs in Grasshopper Creek downstream of Bannack, Montana.

3. Temperatures which could adversely affect growth and propagation of salmonids have been recorded on the Beaverhead, Big Hole, Jefferson, and Madison rivers.

4. High sediment yields exist in the West Gallatin drainage south of Gallatin Gateway, Montana (Plate I), during spring runoff.

5. Severe erosion problems exist in the West Fork of the Madison River drainage (Section III).

6. Sediment yield of the Red Rock River upstream of Lima Reservoir (Figure 1 and Plate I) appears excessive. Nutrient concentrations may also be high.

7. Moderate sediment yields in the Ruby River drainage exist upstream of Ruby Reservoir (Figure 1 and Plate I).

8. Severe sedimentation problems from Muddy Creek (near Dell, Montana) have been identified.

9. Poor irrigation practices on the Parrot Bench near Whitehall may be contributing substantial sediment to the Jefferson River (Bordsen, May 22, 1972).

TABLE 14. UPPER MISSOURI TRIBUTARIES BASIN WATER QUALITY SUMMARY[1]

Sampling Station Designation	Location[2]	Date Sampled	Parameters					
Red Rock River near Dell, MT	12S 9W 20B	9/7/72	Flow (cfs)	295	HCO_3	272	pH (S.U.)	7.80
			Ca	49	Cl	10.0	Specific conductance /cm at 25° C	500
			Mg	21	SO_4	17.3	Turbidity (JTU)	5
			Na	16.1	NO_3	0.27	BOD_5	0.3
			Fe	0.27	F	0.28	D.O.	10
			[3] TR Cu	<0.01	Total coliforms/ 100 ml	170	Temperature	10.0°C
			TR Pb	0.03	TR Cd	<0.01		
			TR Fe	0.32	TR As	<0.01		
			TR Zn	0.01				
Beaverhead River near Twin Bridges, MT	5S 7W 22DBC	9/1/72 - 9/30/72	Flow (cfs)	470	K	6.5	PO_4	0.000
			SiO_2	25	HCO_3	265	Specific conductance /cm at 25° C	618
			Fe	0.01	SO_4	100	pH (S.U.)	8.0
			Ca	61	Cl	17	Suspended Sediment (tons)	552.3
			Mg	27	F	0.6		
			Na	29	$NO_2 + NO_3$	0.18		
Big Hole River near Melrose, MT	3S 9W 34CDD	4/11/73	Flow (cfs)	658	HCO_3	85	pH (S.U.)	7.80
			Ca	19	Cl	2.4	Specific conductance /cm at 25° C	158
			Mg	6.1	SO_4	15	Turbidity (JTU)	4
			Na	8.2	NO_3	3.7	D.O.	10
			TR Cd	0.01	F	0.1	BOD_5	0.9
			TR As	<0.01	TR Pb	0.01	Total coliforms/ 100 ml	17
			TR Cu	0.01	TR Zn	0.07		
			PO_4	<0.01	TR Fe	0.46		

(1) Concentrations are in mg/l (milligrams per liter) unless otherwise indicated.
(2) See Appendix C.
(3) TR = Total recoverable.

Sampling Station Designation	Location	Date Sampled	Parameters					
Ruby River above reservoir near Alder, MT (WQB)	7S 4W 31CCC	10/18/72	Flow (cfs)	16	Cl	6.3	Turbidity (JTU)	4
			Ca	74	SO_4	138	As	0.02
			Mg	25	NO3	0.16	Zn	0.01
			Na	17.5	F	0.62	Cd	<0.01
			Total Fe	0.14	pH (S.U.)	8.30	Pb	0.03
			HCO_3	234	Temperature	8.5° C	Cu	0.01
			Total PO4	0.01	Specific conductance /cm at 25°C	640		
Ruby River near Twin Bridges, MT (WQB)	4S 6W 10BAC	5/18/73	Flow (cfs)	905	Cl	5.5	pH (S.U.)	8.2
			Ca	69	SO4	103	Temperature	12.0°C
			Mg	24	NO3	0.82	D.O.	7.7
			Na	19	F	0.50	BOD_5	1.6
			HCO3	242	Ortho-P-PO4	0.10	As	<0.01
			Specific conductance /cm at 25° C	640	Zn	0.50	Pb	0.04
					Cu	0.01	Fe	3.4
					Total coliforms/ 100 ml	1400		
Jefferson River at Sappington, MT (WQB)	1N 1W 29DCC	5/3/73	Flow (cfs)	2170	SO_4	55	Total Coliforms/ 100 ml	30
			Ca	48	NO3	0.37	Pb	0.01
			Mg	15	F	0.28	Cu	0.01
			Na	18	Turbidity (JTU)	6	Ortho-P-PO_4	<0.01
			HCO3	166	D.O.	11	Cd	<0.01
			CO3	5	Fe	0.50	As	<0.01
			Cl	8.2	pH (S.U.)	8.6	Specific Conductance /cm at 25° C	412
					Temperature	6.0°C		
Boulder River near Boulder, MT (WQB)	5N 4W 3CAD	2/21/73	Flow (cfs)	19	NO_3	0.93	As	0.02
			Ca	22	F	0.06	Zn	1.3
			Mg	6.4	Total-P-PO4	0.19	Cd	0.01
			Na	8.8	pH (S.U.)	7.3	Cu	0.10
			Total Fe	0.45	Temperature	1.0° C	Pb	0.14
			HCO3	75	Turbidity (JTU)	7	BOD5	0.12
			Cl	1.4	Total Coliforms/ 100 ml	2000	Specific Conductance /cm at 25° C	185
			SO_4	42	Dissolved Solids (tons)	157		

Sampling Station Designation	Location	Date Sampled	Parameters					
Madison River near Three Forks, MT (WQB)	1N 2E 20AC	9/21/72	Flow (cfs) . .	1200	NO_3	0.01	As	0.03
			Ca	2.2	F	2.0	Pb	0.07
			Mg	6.8	pH (S.U.) . . .	7.3	Cu	0.04
			Na	23.4	Temperature . .	13.0° C	Zn	0.03
			Total Fe . . .	0.20	Turbidity (JTU)	2	HCO_3	121
			D.O.	10.8	Cl	14	BOD_5	1.4
			SO_4	11.1	Total P-PO_4 . .	0.04		
Gallatin River at Logan, MT (WQB)	2N 2E 35A	9/15/72	Flow (cfs) . .	540	Ortho-P-PO_4 . .	0.05	Turbidity (JTU)	3.6
			Ca	56	F	0.22	As	<0.01
			Mg	18	NO_3	0.03	Fe	<0.01
			Na	12	HCO_3	234	Pb	<0.01
			Cl	9	Temperature . .	14.5° C	Cu	<0.01
			SO_4	27	Total Coliforms/		Zn	0.02
			BOD_5	1.2	100 ml	1060	D.O.	8.1
			pH (S.U.) . .	7.8			Specific conductance /cm at 25° C . . .	610

BEAVERHEAD RIVER

Water discharged from Clark Canyon Reservoir is a very hard, calcium-bicarbonate type with moderate sulfate levels. Water temperatures have been cooler since completion of the dam in 1964 (Aagard, 1969). Turbidities are low, less than two JTU (Jackson Turbidity Units) because most sediments are deposited in the reservoir. Hence, the sediment load discharged from the reservoir is very small. Calcium, magnesium, sodium, and bicarbonate concentrations are approximately 25 percent higher at the downstream station, probably due to the input of groundwater from alluvial deposits along the river noted by Botz (1967).

Water quality or water quality associated problems which may be indicated by studies of the Beaverhead River drainage are:

1. Water temperatures considered high for a salmonid fishery have been recorded at the USGS station near Twin Bridges (Figure 4). Provisional maximum temperature recommended by the Federal Water Pollution Control Administration (now part of the U. S. Environmental Protection Agency) (1968) is 68° F for growth or migration routes of salmonids. Parker and Krendal (1969) report the maximum lethal temperature for brown trout as 25.5° C. Definitive data is not available, but high water temperatures could be due to dewatering, warm irrigation return flows, natural conditions, or a combination. Random sampling by Water Quality Bureau staff on July 10, 1973, indicated significant temperature increases occurred between the USGS station near Dillon and the USGS station near Twin Bridges (Figure 5). Several sloughs in this reach of the river receive irrigation return flows.

2. Wipperman (September 29, 1967) noted dewatering to as much as 90 percent of the average September flow (USGS station at Barretts for the period 1915 to 1959) occurred in various segments of the Beaverhead River between Barretts Diversion and Twin Bridges. Dewatering to similar levels is presumed to occur yearly.

3. Sediment loads carried by the Beaverhead River at the USGS station near Twin Bridges appear

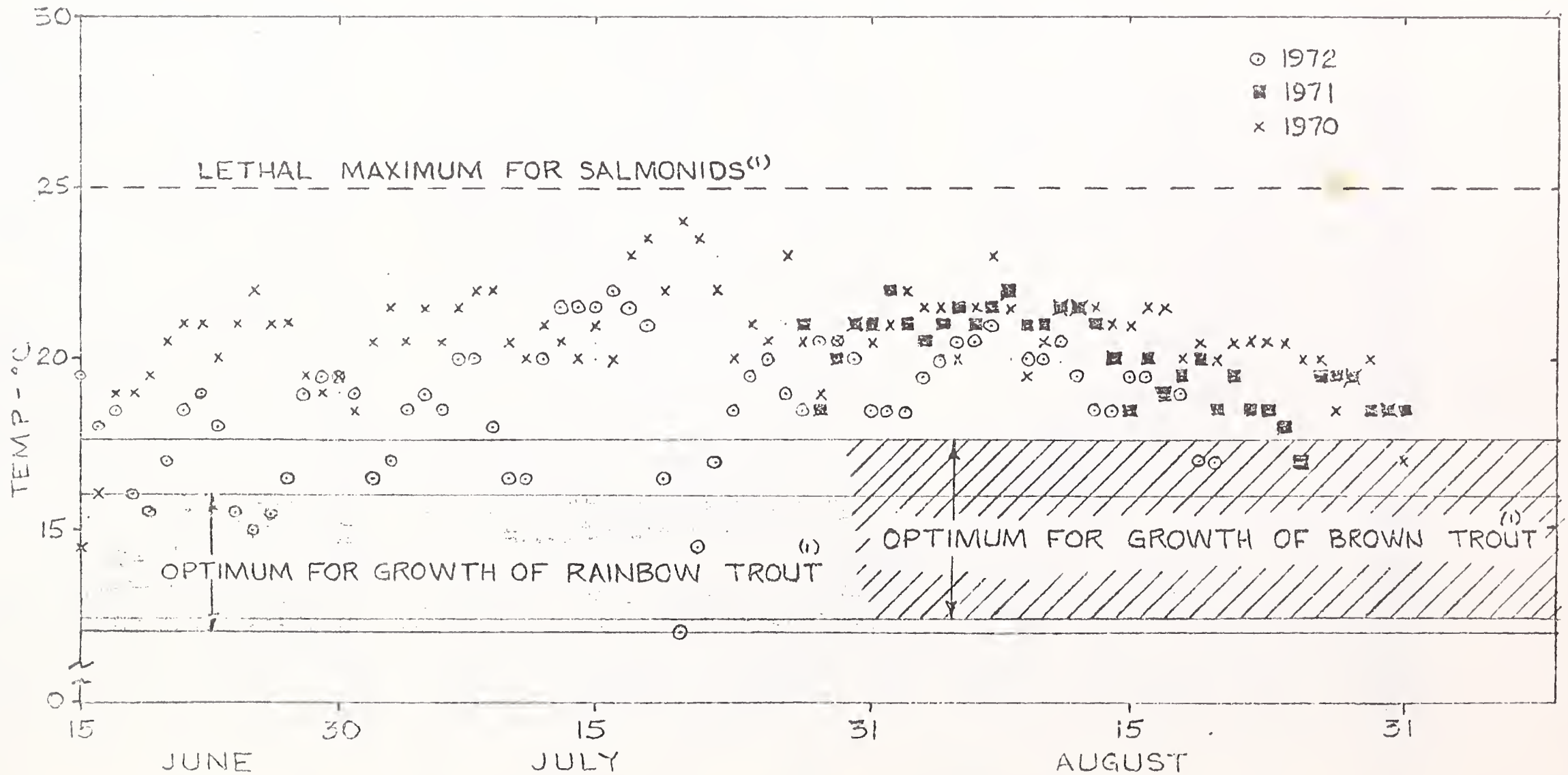

FIGURE 4. BEAVERHEAD RIVER WATER TEMPERATURES NEAR TWIN BRIDGES, MT (USGS Water Resources Data for Montana, 1970, 1971, 1972)

(1) See Section IX.

STATION	Beaverhead River one mile northeast of Dillon, Montana	Beaverhead River at Anderson Lane Bridge	Beaverhead River near Twin Bridges, Montana
LOCATION	7S 8W 7DC	6S 8W 22A	5S 7W 22DB
TIME	1745	1730	1715
TEMPERATURE °C	19.5	23.5	24.0
FLOW - cfs	not measured	59	79

FIGURE 5. WATER QUALITY BUREAU TEMPERATURE MEASUREMENTS OF THE BEAVERHEAD RIVER (JULY 10, 1973)

significantly higher than at the dam outlet. Unfortunately, the types of data collected at both stations (Table 11) are not comparable. So, a quantitative assessment could not be made. Additional study efforts should be directed toward ascertaining the sediment source. They are presumed to be a combination of stream bank erosion on the mainstem and erosion in tributary drainages. Observations by Peterson (July 8, 1974) indicate hydrographic modification of the Beaverhead River by releases from Clark Canyon Dam may be a major reason for stream bank caving on the Beaverhead River. Erosion in the Grasshopper Creek drainage also is believed to be a significant sediment source.

4. Periodic high hydrogen sulfide levels in the Beaverhead River in the Hildreth section (from 2.0 to 3.3 miles downstream of Clark Canyon Dam) have resulted in at least one fish kill and may be adversely affecting the fish population. Decaying aquatic vegetation in the reservoir is the presumed hydrogen sulfide source. Wipperman and Elser (July 17, 1968) reported about 3,000 trout, whitefish and suckers were killed in September, 1967; hydrogen sulfide concentrations as high as two milligrams per liter were measured. Significant hydrogen sulfide levels were also measured in 1965. Wipperman (September 29, 1967) and Wipperman and Elser (July 17, 1968) also noted a distinct paucity of yearling trout in the Hildreth section. Low survival of eggs and/or young fish due to adverse hydrogen sulfide levels is the presumed cause.

5. Grasshopper Creek is believed to contribute a significant sediment load to the Beaverhead River. Grasshopper Creek joins the Beaverhead River about eight miles downstream of Clark Canyon Dam. Based on a Water Quality Bureau field investigation (July 11, 1973), turbidity problems in Grasshopper Creek appear to be due to a combination of factors. About eight of the 15 miles of Grasshopper Creek downstream of Bannack is very confined with much of the stream coursing through a narrow canyon. Because of this confinement, dredge spoils are very high, very steep, and immediately adjacent to the stream. Consequently, these spoils may be easily eroded during spring runoff. Further, vegetative cover reestablishment on the spoils has been poor, so erosion from rainfall and snow melt probably is severe. Placering has been

extensive in this area, and little original ground exists near the stream. Over-utilization of protective vegetative cover by livestock on nearby land appears to have resulted in a deteriorated range condition. Deteriorated range lacks the ability to soak up and hold precipitation; rapid runoff with attendant soil erosion results. Because of these factors, the Grasshopper Creek channel downstream of Bannack is choked with sediment and is unsuitable for the growth and propagation of salmonids. Tarzwell and Gaufin (1953) and Tarzwell (1931) note that streams with shifting sand bottoms support little, if any, aquatic life. Adverse toxic metals concentrations due to past mining downstream of Bannack, Montana, also were presumed to be a major water quality problem in Grasshopper Creek (Montana Water Pollution Control Program Plan, 1974). Limited sampling in July, 1973[1] indicates little apparent change in toxic metals concentrations due to mining activity downstream of Bannack. Background levels, presumably due to mineralization in upper reaches of the watershed, were moderate.

BOULDER RIVER

The Boulder River is a low dissolved solids, moderately hard, calcium-bicarbonate type water with moderate sulfate concentration (Table 14). High toxic metals concentrations from acid mine seeps in the Boulder Batholith region is causing severe pollution of the Boulder River and some of its tributaries (Section VI). Consequently, the Boulder River between Basin, Montana, and the USGS station near Boulder, Montana (Table 11), High Ore Creek, and Cataract Creek do not meet water quality standards for B-D1 streams (Appendix B) and should be reclassified water quality limited.

Toxic metals discharged from mine seeps upstream of Boulder, Montana, are present in the Boulder River in concentrations reported to cause avoidance reactions to migrating fish, thus, blocking existing or potential spawning runs from downstream. Fish food production, fish growth, and spawning success are inhibited severely in some tributaries in portions of the Boulder River (Montana Department of Fish and

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(1) Water Quality Bureau (July 11, 1973) and Miller, et.al. (March, 1974).

Game, March 1, 1972, and Elser and Marcoux, April 28, 1972). Table 15 summarizes Boulder River toxic metals concentrations. Water quality impairment is due principally to input of sediment and toxic metals from the High Ore and Cataract Creek drainages (Table 16). In addition, substantial amounts of mill tailings have been eroded from the inactive Jib Mine at Basin, Montana. Mining activity in other portions of the Boulder River drainage has resulted in several less significant problem areas. History and development of mining in the Boulder River drainage has been discussed by Roby, et.al. (1960).

TABLE 15. TOXIC METALS CONCENTRATIONS IN THE BOULDER RIVER, MONTANA.

Parameter	Boulder River Near Boulder, MT[1] (February 21, 1973)	Boulder River at Basin, MT, above Basin Creek (September 5, 1973)	Boulder River at Highway 10 Bridge near Cardwell, MT (February 21, 1973)	Concentrations (mg/l) at which Various Elements Become of Biological Interest[2]
TR Fe	0.45	0.10	0.10	0.02
TR Cu	0.10	<0.01	0.05	0.001
TR Zn	1.3	<0.01	0.23	0.001
TR Mn	-	0.01	-	0.1
TR As	0.02	<0.01	<0.01	0.3
TR Cd	0.01	-	<0.01	0.001
TR Pb	0.14	-	0.04	0.01
Cu	-	<0.01	-	-
Zn	-	<0.01	-	-
Mn	-	<0.01	-	-
Fe	-	<0.01	-	-

(1) See Table 10 for geographic location.
(2) Horpestad (1974). Values given are for one-tenth of acute toxicity levels. Most values are developed from acute toxicity levels listed in Water Quality Criteria by McKee and Wolf, California State Water Resources Board, Second Edition, 1963.

TABLE 16. MINING POLLUTION IN THE BOULDER RIVER DRAINAGE UPSTREAM OF BOULDER, MONTANA

Sampling Station Designation	Location[2] (Drainage)	Date Sampled	Remarks	Parameters[1]	
Crystal Mine	7N 5W 20B (Cataract Creek)	8/9/74	Acid and toxic metals drainage and tailings erosion at inactive adit; soil erosion from haul road and overburden at active open pit site.	Flow . . . . 50 gpm (estimate) TR Fe . . . 218 TR Zn . . . 4750 TR Cd . . . 2.5 TR Cu . . . 62	 TR Mn . . . . 35 TR As . . . . 12 TR Ag . . . . TR Pb . . . .
Cataract Creek at Forest Service Bridge at Eva May Mine	7N 5W 22BBA (Cataract Creek)	6/13/74	Cataract Creek above mining activity.	Flow . . . . 15 cfs (estimate) Specific conductance . . 59 μ/cm at 25° C Temperature 4.5° C pH . . . . . 7.5 S.U. Turbidity . 5 JTU TR Zn . . . 0.06	 TR Fe . . . . 0.52 TR Pb . . . . 0.02 TR Cu 0.03
Eva May Mine, Adit Drainage	7N 5W 22BBD (Cataract Creek)	6/13/72	Acid and toxic metals drainage. Mine active.	Flow . . . . 5 gpm (estimate) Specific conductance . . 670 μ/cm at 25° C pH . . . . . 6.8 S.U. Turbidity . <2 JTU TR Zn . . . 0.25 TR Cu . . . 0.09	 Temperature . 7.0° C TR Fe . . . . 2.40 TR Pb 7.6
Cataract Creek at Forest Service Bridge near Big Limber Gulch	6N 5W 9CBB (Cataract Creek)	9/15/72	Mining pollution upstream.	Flow . . . . 3.4 cfs Specific conductance . . 160 μ/cm at 25° C pH . . . . . 7.7 S.U. Ca . . . . . 21 Mg . . . . . 4.8 Na . . . . . 3.9 TR Fe . . . 0.19 TR Cu . . . 0.04 TR Pb . . . 0.02	Temperature . 7.0° C Turbidity . . 2 JTU HCO_3 . . . . 68 Cl . . . . . 0.0 SO_4 . . . . . 21 TR Zn . . . . 0.10 TR As . . . . <0.01

(1) All values reported are in mg/l (milligrams per liter) unless otherwise shown. TR = total recoverable.
(2) See Appendix C.

Sampling Station Designation	Location(2) (Drainage)	Date Sampled	Remarks	Parameters(1)
Cataract Creek at U. S. Highway 91	6N 5W 16D (Cataract Creek)	8/23/72	Sample collected after all-night rain. Sediment from Crystal Mine and inactive placer operation upstream.	Flow . . . . 5 cfs (estimate) Turbidity . 230 JTU SS 98
Seep in Comet Mine tailings area, 100 yards above toe of tailing	6N 5W 2AA (High Ore Creek)	6/5/73	Acid and toxic metals drainage. Mine inactive	Flow . . . . 3 gpm (estimate) Specific conductance . . 682 μ/cm at 25° C Temperature 7.0° C pH . . . . . 6.7 S.U. Ca . . . . . 89 TR Fe . . . . 10 Mg . . . . . 21 TR Cu . . . . 0.01 HCO_3 . . . . 150 TR Pb . . . . 0.01 TR As . . . 0.34 TR Cd . . . . <0.01 TR Zn . . . 18
Effluent from Comet Mine tailings	6N 5W 2AA (High Ore Creek)	6/5/74	Acid and toxic metals drainage and tailings erosion. Mine inactive.	Flow . . . . 10 gpm Specific conductance . . 1546 μ/cm at 25° C Temperature 11.0°C pH . . . . . 6.6 S.U. Ca . . . . . 157 TR As . . . . 0.22 Mg . . . . . 61 TR Cd . . . . 0.01 HCO_3 . . . . 112 TR Zn . . . . 36 TR Cu . . . <0.01 TR Pb . . . . <0.01
High Ore Creek at mouth	6N 5W 22AA (High Ore Creek)	4/10/73	Acid and toxic metals drainage and tailings erosion from Comet Mine area.	Flow . . . . 2 cfs (estimate) Specific conductance . . 352 μ/cm at 25° C Temperature 2.0° C Turbudity . . 1150 JTU Ca . . . . . 45 SO_4 . . . . . 98 Mg . . . . . 11.9 TR Cd . . . . 0.01 Na . . . . . 5.5 TR Pb . . . . 8.2 HCO_3 . . . . 89 TR Cu . . . . 0.11 Cl . . . . . 1.3 TR As . . . . 8.0 TR Fe . . . 107

(1) All values reported are in mg/l (milligrams per liter) unless otherwise shown. TR = total recoverable.
(2) See Appendix C.

BIG HOLE RIVER

The Big Hole River generally is an excellent quality, moderately hard, calcium-bicarbonate type water with low turbidity and low sulfate, sodium, chloride, and toxic metals concentrations (Table 14). However, stream temperatures considered adverse for growth and propagation of salmonids and associated aquatic life have been recorded downstream of the USGS station near Melrose, Montana (Figure 6). Temperature fluctuations appear somewhat cyclic and may be affected by diversion for irrigation. Miller (January 15, 1974) reports the number of irrigation diversions between Divide Dam(1) and the mouth of the Big Hole River increased from 26 in 1970 to 44 in 1973. The Big Hole River near Twin Bridges, Montana, was dry for a period of time during the summer of 1966 (Wipperman, September 3, 1974). Secondary effects of channelization and construction of diversion works for irrigation are an increase in stream sediment loads and turbidities.

GALLATIN RIVER

A detailed waste load allocation study of the Gallatin drainage (Section III) was conducted for the U. S. Environmental Protection Agency by Stuart, et.al. (July 25, 1974). The study concluded the West Gallatin River is a high quality, low total dissolved solids, and low nutrient mountain stream for most of its approximately 110-mile length. Only after its confluence with Baker Creek, about five miles upstream from the junction with the East Gallatin River, were turbidity, dissolved ions, and nutrients increases evident after spring runoff. Baker Creek originates in and drains an area of intensive agricultural activity. During spring runoff, high sediment yields are attributed to easily eroded sedimentary formations in the steep, mountainous upper portion of the watershed and to stream bank erosion in the lower valley segments (Klages, 1972, and Hsieh, 1972). Although not discussed in the study, construction activities at Big Sky of Montana have reportedly contributed quantities of suspended solids to the West Gallatin River (Stuart, et.al., July 25, 1974).

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(1) About three miles upstream from Divide, Montana. Geographic location is 1S 10W 11D.

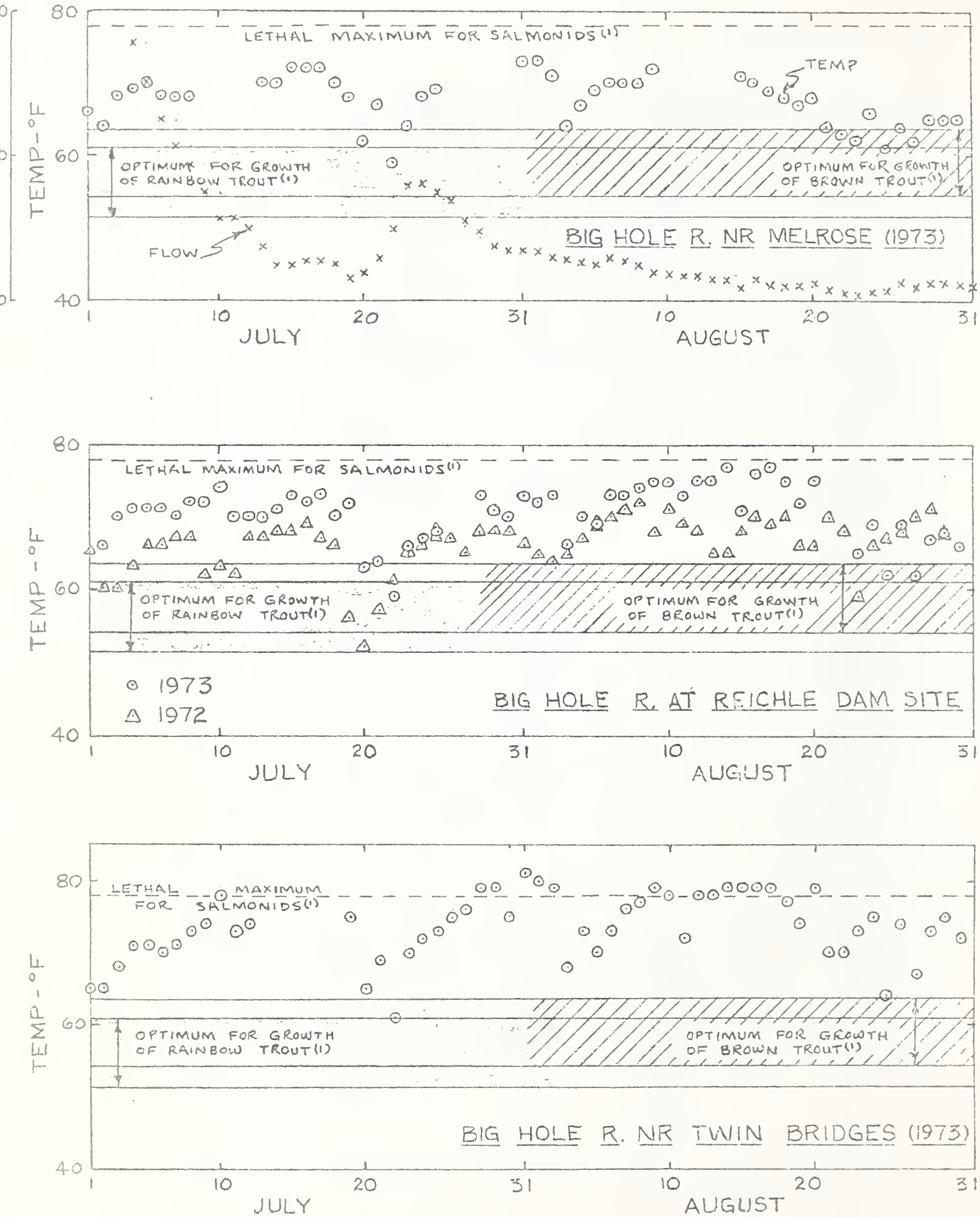


FIGURE 6. MAXIMUM DAILY WATER TEMPERATURES FOR THE BIG HOLE RIVER, MONTANA (Peterson, July 11, 1974)

(1) See Section IX.

Water quality of the East Gallatin River is poorer than that of the West Gallatin River. Erosive stream banks, extensive agricultural activity, and the discharge from Bozeman's sewage treatment plant are major factors contributing to this increased dissolved solids, high nutrients, and high coliform counts noted (Stuart, et.al., July 25, 1974). The East Gallatin River flows through agricultural land for all of its length.

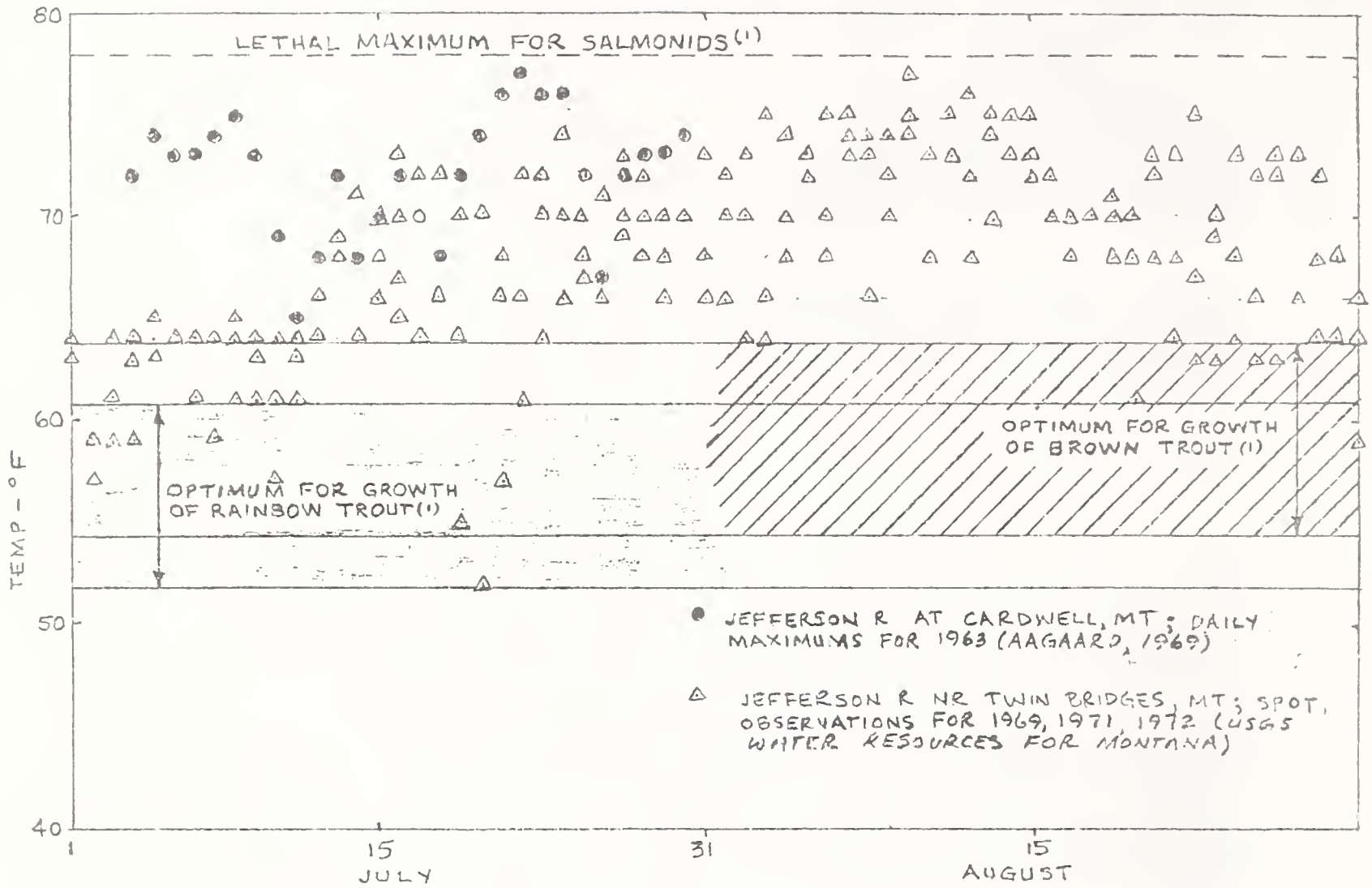
Water quality of the Gallatin River at Logan, Montana, (Table 14) about five miles downstream of the confluence of the West and East Gallatin rivers generally is good.

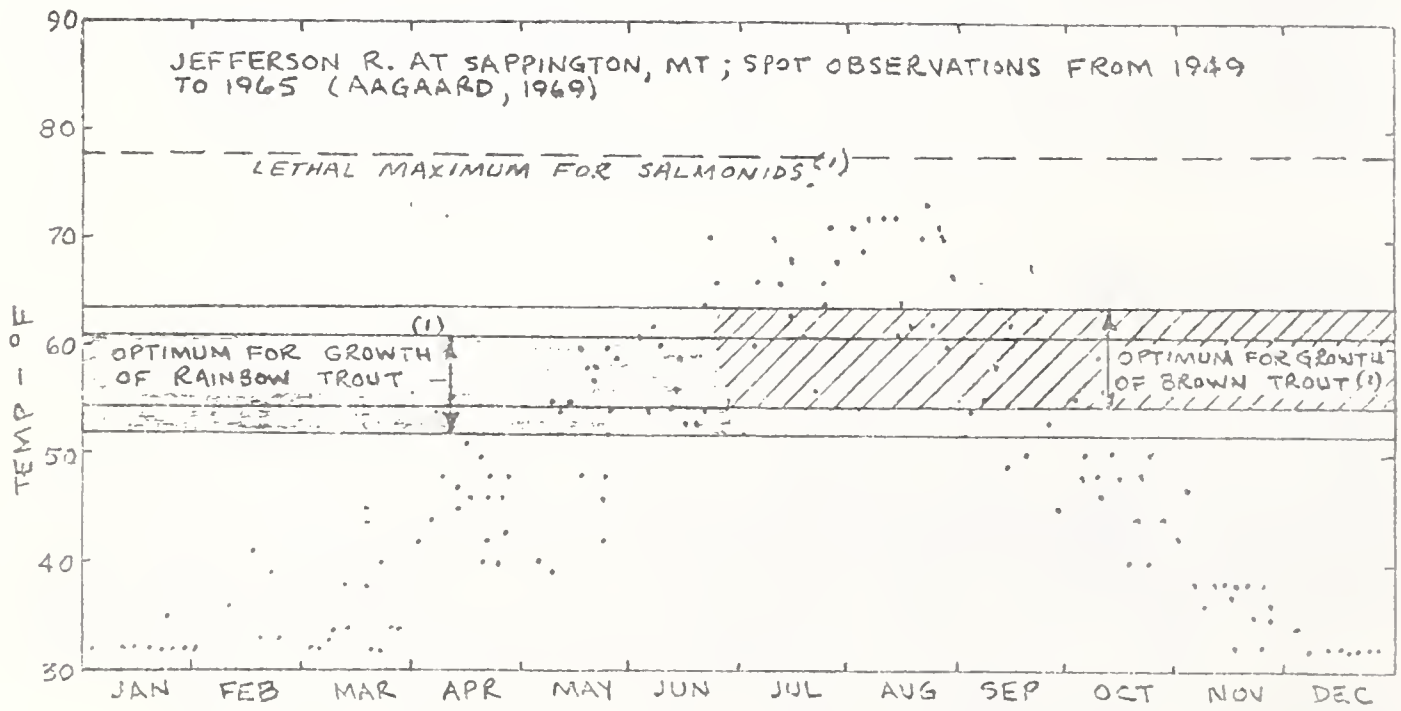
JEFFERSON RIVER

The Jefferson River is a very hard, calcium-bicarbonate type water with moderate sulfate, sodium, magnesium, and chloride concentrations (Table 14). Moderate turbidities, 3 JTU (Jackson turbidity units) to 14 JTU were recorded from September, 1972, to April, 1972, probably were due to a number of complex and inter-related causes. Among these may be irrigation return flows, natural erosion, and channel erosion of the Lower Ruby and Beaverhead rivers due to hydrographic modification, overgrazing, and livestock wintering operations along stream bottoms. Bordsen (1972) noted poor irrigation practices on the Parrot Bench (near Whitehall, Montana) were causing moderate erosion which may be reaching the Jefferson River. Stream temperatures considered adverse for salmonids and associated aquatic life have been recorded (Figure 7). Toxic metals concentrations are low.

MADISON RIVER

Protection of the generally high quality water of the Madison River drainage is not only desirable but an essential economic element of the area and the state. In 1970 alone, high water quality of the Madison River directly influenced the expending of 125,000 fisherman-days and 65,000 hunter-days in the drainage (Bureau of Reclamation, 1971). Agriculture, the major industry of the area, also is dependent on high quality water. Quality of the Madison River is also important to downstream cities of Great Falls, Helena, and Fort Benton, which use the Missouri River for municipal supply. The Madison River is a major tributary of the Missouri River.





(1) See Section IX.

FIGURE 7. SPOT OBSERVATIONS OF WATER TEMPERATURES AT SELECTED JEFFERSON R LOCATIONS

The Madison River is a calcium-bicarbonate, moderately hard water of generally excellent quality (Table 14). Gradual increases in dissolved mineral concentrations occur with decreasing distance from the three forks of the Missouri River. However, changes were small and the overall excellent water quality was not impaired. The Madison River would be a good source for public supply, but treatment would be necessary to control turbidity, arsenic, and fluoride. Turbidity is moderate during spring runoff, and arsenic and fluoride generally exceed 0.05 mg/l (milligrams per liter) and 1.7 mg/l, respectively, the U. S. Public Health Service limits (Table 17).

Sediment eroded from the West Fork of the Madison River and transported to the mainstem appears to be the major water quality problem in the Madison River drainage. Heavy sediment loads carried by the West Fork during spring runoff change the mainstem from clear to turbid after mixing. Records of the U. S. Forest Service (Demuele, 1973) indicate over 10,000 tons of sediment annually enter the Madison River from its West Fork. Lisle (1972) states the major cause is overgrazing by sheep, particularly that done prior to 1926. Overgrazing, particularly along the southern crest of the Gravelly Range, has damaged grass cover, resulting in increased runoff. The West Fork is responding to the increased flow (runoff) by increasing its channel width at the rate of about 5 cm (centimeter) per year in its lower reaches. As of 1971, Lisle (1972) estimated 36 percent of the grazed area of the upper West Fork (southern crest of the Gravelly Range) was still overstocked with sheep and that continued overgrazing by sheep prevented the drainage from returning to its former equilibrium state. Cattle grazing in the drainage have not been important. Erosion associated with off-road vehicular travel and the Standemeyer irrigation ditch (diverts water of the West Fork into the Red Rock River drainage) were contributing to the problem. The Standemeyer ditch is downcutting rapidly and constitutes a serious geologic hazard in terms of erosion and landsliding (Lisle, 1972). Logging in the drainage has not aggravated the problem. Recommendations were to phase out grazing in the watershed and prohibit off-road vehicular travel (Lisle, 1972).

Temperatures considered adverse for salmonids and associated aquatic life have been recorded upstream of Hebgen Lake (near West Yellowstone, Montana) and

TABLE 17. ARSENIC, FLUORIDE, AND TURBIDITY MEASUREMENTS OF THE MADISON RIVER NEAR CAMERON, MONTANA(1)

Date	Flow - cfs	As - mg/l	F - mg/l	Turbidity - JTU
5/24/73	2,360	0.01	2.0	-
4/26/73	1,340	0.03	2.5	2.0
3/23/73	1,350	<0.01	3.0	1.0
2/1/73	-	0.07	2.6	1.0
10/18/72	-	0.11	-	2.0
9/8/72	1,520	0.08	2.0	1.0
8/11/72	1,420	0.05	1.8	1.4
7/7/72	1,560	0.03	0.6	4.0
6/16/72	3,280	0.03	1.2	7.0
5/12/72	5,850	0.02	3.0	3.4
3/23/72	1,520	0.09	3.2	2.8
2/24/72	-	-	2.4	-
1/20/72	-	-	3.2	-

(1) Geographic location is 7S 1W 8DCC. See Table 11 for other parameters

downstream of Ennis Lake (near Ennis, Montana) by the Montana Department of Fish and Game (Heaton, 1961 and 1962). Maximum water temperatures up to 81° F recorded upstream of Hebgen Lake were attributed to thermal activity in Yellowstone Park. Temperatures above 70° F were common in the Madison River downstream of Ennis Lake. A maximum of 82° F was recorded at the confluence with Cherry Creek [near the Beartrap(1) Canyon outlet]. Other temperature measuring stations downstream of Ennis Lake were at the USGS station near McAllister, Montana, and near the river's mouth. Ennis Lake, a broad, shallow Montana Power Company impoundment near Ennis, Montana, has been shown to increase the mean temperature of the Madison River. Flow releases from Hebgen Dam, a major Montana Power Company storage reservoir, are also an important factor influencing stream temperatures in the Madison River.

RED ROCK RIVER

The Red Rock River is a very hard, calcium-bicarbonate type water with moderate sulfate, sodium, magnesium, and chloride concentrations (Table 14). Lead, zinc, cadmium, and copper concentrations generally were low and are attributed to geology of the area. However, low flow turbidities recorded were significantly higher than other major streams (except the Ruby River) discussed in this report (Table 18).

Erosion of easily eroded soils in the drainage is the likely cause of moderate turbidities. Lisle (1972) reported erosion in the West Fork of the Madison River drainage is due chiefly to overgrazing in the southern crest of the Gravelly Range. A portion of the southern crest of the Gravelly Range is drained by the Red Rock River. So, overgrazing also may be a problem in at least a portion of the Red Rock River watershed. Temperatures considered adverse for propagation and growth of salmonids and associated aquatic insects were not recorded and were not indicated in the literature.

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(1) The Beartrap Canyon is a deep, narrow canyon which begins at the outlet of Ennis Lake and contains the Madison River for the next seven miles.

TABLE 18. TURBIDITY MEASUREMENTS OF THE RED ROCK RIVER

Station	Geographic Location	Date	Flow - cfs	Turbidity - JTU
Red Rock River at first bridge upstream of Lima Reservoir	13S 4W 6CD	7/12/73	NM(1)	14
Red Rock River at Lima Dam	12S 6W 32CC	7/12/73	440	10
Red Rock River near Lima, Montana	14S 8W 4DAAA	7/20/72	495	13
		6/27/73	610	8
Red Rock River at USGS Station near Dell, Montana	12S 9W 20DBC	8/10/72	900	5
		9/7/72	295	7
		10/4/72	NM	7
		12/19/72	NM	7
		3/8/73	NM	5
		4/11/73	50	35
Red Rock River at Interstate Highway 90 bridge near Red Rock, Montana	10S 10W 33DD	10/4/72	NM	6

(1) Not measured.

RUBY RIVER

The Ruby River is a very hard, calcium-bicarbonate type water with moderate sulfate, sodium, and magnesium levels and low chloride concentrations. Lead, zinc, cadmium, and copper levels generally were low and are due to geology of the watershed. Turbidities recorded (Table 19) during low flow periods were moderate and also higher than all other major streams discussed (Section VIII) except the Red Rock River. Erosion of easily eroded soil in the watershed is the likely cause of turbidities noted. Poor land management practices, particularly overgrazing, are believed to have severely aggravated erosion in the drainage (Section VI). Lisle (1972) identified overgrazing as the major factor causing erosion in the West Fork of the Madison River portion of the southern Gravelly Range. The Ruby River drains a portion of the southern end of the Gravelly Range. So, overgrazing may also be a major cause of erosion in the Ruby River drainage.

TABLE 19. TURBIDITY MEASUREMENTS OF THE RUBY RIVER

Station	Geographic Location	Date	Flow - cfs	Turbidity - JTU
Ruby River approximately four miles upstream from Vigilante Ranger Station	10S 3W 16CAD	8/23/72	100	25
Ruby River at USGS station above reservoir near Alder, MT	7S 4W 31CCC	8/10/72	100	2
		8/23/72	156	5
		9/7/72	143	4
		10/18/72	16	4
		1/25/73	136	6
		3/15/73	330	6
		4/19/73	146	14
		6/26/73	150	16
Ruby River at USGS station at Ruby Dam near Alder, MT	7S 4W 8ADC	9/5/72	298	<0.9
		10/4/72		
		1/25/73	66	5
		3/15/73	74	5
		4/19/73	96	7
Ruby River at USGS station near Twin Bridges, MT	4S 6W 10BAC	8/9/72	103	6
		9/6/72	520	4
		10/4/72	NM(1)	6
		1/25/73	NM	4
		3/15/73	NM	4
		4/19/73	100	7

(1) Not measured.

IX. FISHERY ASSESSMENT

Cold-water habitats of streams in the Upper Missouri tributaries basin have provided some of the finest trout fisheries in the United States. Three of Montana's seven blue ribbon[1] streams (Madison, Big Hole and Gallatin Rivers) are present in the basin. However, the health of many streams in the basin, reflected in the aquatic communities which they support, may be declining.

Montana university system research (Section III), complaints received by the Department of Health and Environmental Sciences (DHES), recent enforcement action by the DHES (Section V), and studies by the Montana Department of Fish and Game indicate there are serious water quality and water quality related problems in the basin. These may be reflected in electrofishing results (Table 20). Armstrong Spring Creek, Rock Creek, Big Spring Creek, and the Madison River are considered examples of biologically healthy streams, but direct comparison between streams is not valid. So, data presented should be considered qualitative.

Tarzwell (1953) notes the severest threat to a fisheries usually is the gradual increase in pollution which slowly destroys the population in such a way that the decline in the fish population escapes public protest. Conversely, fish kills due to occasional spills of pollutants generally are much less harmful but attract a great deal of attention. According to Kendall (1924), some stream fisheries in the eastern United States were degraded over such a long period of time that their potential is no longer realized. Interestingly, Whitlock, (1972) feels the fisheries of western streams are declining because of increased angling pressure, dewatering, and various pollution forms, noting a similar trend occurred on streams in the eastern United States around the turn of the century.

Section 69-4801 of Montana's law regarding water pollution states in part:

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(1) Blue ribbon streams are streams with trout fisheries of national importance.

TABLE 20. TROUT POPULATIONS IN SOME MONTANA STREAMS

Stream	Segment (Description)	Flow - cfs[9] Average	Minimum	Date	POPULATION DATA lbs/1000 ft	lbs/surface acre	No./1000 ft	No./surface acre	Reference
Big Hole River	Reichle Segment (begins 1.5 miles downstream of Reichle dam site and extends downstream 4.5 miles)	1,137[6]	49[5,6]	March-April, 1973	137	NM[1]	130	NM[1]	Peterson (February, 1974)
Ruby River	Section 1 (bulldozed) (near Laurin, Montana)	220[4]	19[4,5]	July, 1973	55[2]	NM[1]	81[2]	NM[1]	Peterson (February, 1974)
Ruby River	Section 2 (natural) (near Laurin, Montana)	220[4]	19[4,5]	July, 1973	133[2]	NM[1]	255[2]	NM[1]	Peterson (February, 1974)
Rock Creek[3]	Fish and Game (about 13 miles upstream from mouth)	324[8]	52[5,8]	September, 1972	92	NM[1]	270	NM[1]	Marcoux (March 20, 1974)
Madison River	Norris (begins at junction with Warm Springs Creek and extends to junction with Cherry Creek)	1,732[7]	210[5,7]	March, 1971	338	NM[1]	581	NM[1]	Vincent (January 30, 1973)
Big Spring Creek[3]	Burleigh's Section (upstream from Lewistown)	107[10]	76[5,10]	Sept. 1974	not available	NM[1]	179	NM[1]	Poore (October, 1975)

(1) NM = not measured.
(2) Data are for brown trout; other species not significant.
(3) Not in Upper Missouri tributaries basin.
(4) Measured at USGS station 06020600, Ruby River below reservoir, near Alder, Montana.
(5) Minimum daily or minimum observed flow.
(6) Measured at USGS station 06025500, Big Hole River near Melrose, Montana.
(7) Measured at USGS station 06041000, Madison River below Ennis Lake, near McAllister, Montana.
(8) Measured at USGS station 12334510, Rock Creek near Clinton, Montana.
(9) cfs = cubic feet per second.
(10) Measured at USGS Station 1115. Big Spring Creek near Lewistown, Montana.

It is the public policy of this state to conserve water by protecting, maintaining, and improving the quality and potability of water for public water supplies, wildlife, fish and aquatic life, agriculture, industry, recreation, and other beneficial uses.

Degradation and destruction of the resident fisheries and associated aquatic life through physical habitat alteration appears to be contrary to this policy statement.

Section 69-4802 of Montana's law regarding water pollution states in part:

Pollution means such contamination, or other alteration of the physical, chemical or biological properties, of any state waters, as exceeds that permitted by Montana water quality standards . . .

Montana water quality standards for A-Open-D_1 and B-D_1 streams (Appendix B), which includes most of the streams in the Upper Missouri tributaries basin, states in part:

The quality is to be maintained suitable for growth and propagation of salmonid fishes and associated aquatic life . . .

State surface waters are to be free from substances attributable to municipal, industrial, agricultural practices, or other discharges that will create concentrations or combinations of materials which are toxic or harmful to human, animal, plant, or aquatic life.

The secondary effects of physical alterations to a stream, i.e., increased temperature and turbidity, could violate the above.

Alteration of stream channels is important biologically because habitat may be destroyed and adverse water quality changes may result. Channel straightening and realignment probably is the worst offender in causing bank caving and stream bottom scour because velocity increases obtained may exceed stability velocities (EPA, September, 1973). So, increased stream sedimentation results. Further, the phenomenon of sediment deposition tends to migrate upstream, clogging channels and defeating the purpose of

channelization and realignment (EPA, September, 1973). Shortening a stream channel also decreases the time of concentration and may result in the flooding of downstream areas. Maximum and minimum water temperatures are increased and decreased, respectively, when channels are widened because stream flow is directed to the center of channel and deprived of any bankside shade. Removal of streamside vegetation adds to the problem (EPA, September, 1973 and Brown, 1970). Heavy recreational and livestock use may also result in the destruction of bankside vegetative cover, resulting in adverse temperatures and the creation of stream bank instability (Bullard, 1965, Corning, 1969). Wesche (1973) has found brown trout exhibit a strong habitat preference for undercut banks as opposed to instream rubble-boulder areas. In a study of Rock Creek near Red Lodge, Montana, Gunderson (1966) found heavy grazing greatly changed that stream's morphology, resulting in a significant decrease in the pounds of trout per 1,000 feet of stream. Whitney and Bailey (1959) found the number and weight of salmonids greater than six inches decreased 94 percent in a segment of Flint Creek near Philipsburg, Montana, after channelization for highway construction.

The sediment load carried by streams is important because:

1. Suspended sediment reduces light penetration, hence reducing the growth of phytoplankton and other aquatic plants. Phytoplankton and other aquatic plants are the base of the aquatic food chain (Hershall, 1920 and EPA, September, 1973).

2. Sediment may cause the destruction of fish eggs and aquatic insect larvae by blanketing fish spawning areas and productive stream bottom areas (Hershall, 1920; EPA, September, 1973; Needham, 1928, 1934; and Pote, 1932). The detrimental effects of sediment on the survival of trout eggs has been demonstrated by Bianchi (1963) and Corning (1959).

3. Pools may be filled and areas of fish cover may be lost due to sediment deposition (EPA, September, 1973; Hershall, 1920; Needham, 1928, 1934; and Pote, 1932).

4. Excessive stream sediment may also increase costs to downstream water users, decrease aesthetic

values, and cause channel instabilities leading to further erosion and sediment problems (EPA, September, 1973).

Belding (1928) notes even slight increases in temperature of trout streams generally are undesirable. Further, streams which become too warm only one day per year cease to be trout streams (Needham, 1938). The maximum temperature which any of the trout species for even brief periods of exposure appears to be about 82° F (Embody, 1921 and MiGonigle, 1934). Specie selection, food availability, attendant life cycle chemistry, and water quality changes are all affected by temperature (EPA, September, 1973). Further, not only absolute temperature but also temperature variation affect fish and associated aquatic life (EPA, September, 1973).

Lethal and preferred temperatures for some salmonids found in the Upper Missouri tributaries basin are given in Table 21. Parker and Krenkel (1969) noted some disagreement among authorities. Different acclimation temperatures were used for some experiments and may have caused some of the spread.

TABLE 21. LETHAL AND PREFERRED TEMPERATURES FOR SOME SALMONIDS

Species	Temperature - °C Lethal	Preferred
Salmo gaidneri (rainbow trout)	-	11 - 16
Salvelinus fontinalis (brook trout)	24 - 25	12 - 16
Salmo trutta (brown trout)	25.5	12.4 - 17.6

Provisional maximum temperature recommended by the Federal Water Pollution Control Administration(1) (1968) is 68° F for growth or migration routes of salmonids.

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(1) Now part of the U. S. Environmental Protection Agency.

Reduced stream flows are biologically important because available habitat may be reduced, water temperatures may increase because the stream's effective depth is reduced, and the benthic community population and diversity may be reduced. Bell (1971) notes food organisms for trout typically have a one-year life cycle and do not reestablish themselves in areas alternately wetted and dried. Bell (1971) estimates six to seven pounds of food are required for each one pound of trout produced if conditions are optimum. In a study of two Wyoming trout streams, Wesche (1973) found a minimum flow of approximately 25 percent of the average daily flow would avoid serious habitat destruction. In another study, Tennant (1972) found that a flow of 10 percent of the mean annual flow could be considered only a short-term survival flow at best and that any flow which would exceed 30 percent of the mean annual flow can be considered a satisfactory fishery flow. Excessive stream flows are also important. In a study of three Colorado streams, Corning (1969) found excessive dam releases washed gravel spawning beds away, resulting in poor survial of fertile rainbow trout eggs.

BIG HOLE RIVER

Brook trout and mountain whitefish are abundant in the Big Hole River drainage upstream from its confluence with the Wise River (Plate I). Arctic grayling, once native to the entire Big Hole River drainage, is now restricted primarily to this section. Rainbow and brown trout and mountain whitefish are the dominant game fish in the Big Hole River below Wise River (Marcoux, November, 1974).

Agricultural activities may have degraded the fisheries of the Big Hole River. Extensive dewatering for irrigation may have resulted in increasing temperatures--some as high as 81° F near the mouth (Miller, January 15, 1974). Fish kills, primarily whitefish, have occurred during the summer dewatering period. Many channels have been bulldozed to get water to headgates or to deliver the stream into other areas (Peterson, February 15, 1974). In 1970, Miller (January 15, 1974) counted 26 irrigation diversions from the Big Hole River between Divide Dam (about 14 miles upstream from Melrose, Montana) and Twin Bridges, Montana. By 1973, this number had increased to 44 in this reach of the river. In addition,

Willow and Birch creeks, tributaries of the Big Hole River downstream of Melrose, Montana (Plate I) are diverted into the Beaverhead River for irrigation of about 5,000 acres (USGS Water Resources Data, 1973). National public interest concerning destruction of natural streams such as the Big Hole River, is manifest in articles appearing in FLY FISHERMAN (June 1974), OUTDOOR LIFE (December 1974) and other magazines.

The Big Hole River is listed as a blue ribbon trout stream by the Montana Department of Fish and Game; however, recent electrofishing surveys indicate the fishery may be average at best (Table 20). Based on observations of the indigenous biological community, Marcoux (February 3, 1975) believes trout populations in the Big Hole River downstream of Melrose, Montana, are stable but could be significantly greater if summer flows were not so low.

RUBY RIVER

Rainbow, brown, and cutthroat trout are the dominant game fish species in the Ruby River upstream of Ruby Reservoir. Brown trout and whitefish are the dominant game fish species downstream of Ruby Reservoir. Suckers and sculpin also are common in the drainage (Marcoux, November, 1974).

Wipperman (September 29, 1967) noted a large brown trout population (Table 20) despite deteriorating habitat conditions, but also noted the fish were in poor physical condition (skinny, slow growth).

RED ROCK RIVER

The Red Rock River in the vicinity of Red Rock Lakes once supported an abundant Arctic grayling population; however, overgrazing and irrigation diversions are believed to have been a major factor in their decline (Marcoux, November, 1974). The introduction of brook trout also may have contributed to the decline of grayling in the upper Red Rock River drainage. Brook, rainbow, and cutthroat trout are found in many tributary streams where cover is available (Marcoux, November, 1974). Marcoux (November, 1974) reports few, if any, game fish are found in the Red Rock River between the Red Rock Lakes and Lima Reservoir, primarily because of high water

temperatures and high sediment loads. Ling and two or three species of suckers are the dominant fish species. Lima Reservoir is shallow, resulting in high water temperatures which inhibit trout productivity downstream.

Cutthroat, brown, rainbow, and brook trout and mountain whitefish are the important game species found in the Red Rock River below Lima Reservoir. Sculpins, ling, and suckers are also present in this reach of the river. Shutoffs for dam inspections have had a detrimental effect on the downstream fishery (Marcoux, November, 1974).

BEAVERHEAD RIVER

Brown and rainbow trout and whitefish are the dominant game fish species found in this stream. Other fish present are sculpins, suckers, and carp. The Beaverhead River is considered an excellent salmonid fishery (Marcoux, November, 1974). However, Wipperman (September 29, 1967) reports fluctuating water levels caused by releases from Clark Canyon Reservoir and withdrawals caused by releases at Barretts Diversion may influence reproduction and survival of trout populations in the river. Decreased fish populations in the lower Beaverhead River (downstream of Dillon) may be a result of agricultural activity in this segment (Marcoux, 1974).

BOULDER RIVER

Cutthroat, rainbow, and brook trout are the predominant game fish species in the drainage upstream of Boulder, while brown trout predominate downstream of Boulder (Marcoux, November, 1974). The Boulder River has a history of providing excellent fishing; however, recent surveys indicate many problems exist, which in combination, severely reduce the fishery.

Surveys on tributaries of the Boulder in the Basin to Boulder area show many mining problems contribute to poor water quality (Elser and Marcoux, April, 1972). High levels of zinc, lead, and copper are found in the sediments below the mouth of the Little Boulder (Marcoux, November 1974). High water temperatures to 82° F have been recorded and are a result of dewatering and the lack of cover in the wide, exposed channel below the

Elkhorn road (Marcoux, November, 1974). Heavy sediment deposits are evident in many areas below Boulder--some are a result of a tailings spill many years ago and others are a result of losses from an alluvial fan in the Nigger Hollow area (Marcoux, November, 1974).

JEFFERSON RIVER

Brown trout and whitefish are the major game fish species in this river. Rainbow trout, carp, and suckers are also present in the Jefferson River. Water quality of the Jefferson River is dependent on its main tributaries, the Ruby, Beaverhead, and Big Hole rivers. Extensive dewatering of tributaries and the Jefferson River proper has resulted in complete dewatering in some areas (Marcoux, November, 1974).

MADISON RIVER

Brown and rainbow trout are found in the main river with rainbow trout dominant upstream of Ennis Lake. Arctic grayling were once abundant in the Madison; however, only a remnant population remains. Mountain whitefish, sculpins, and three species of suckers are common in the drainage (Marcoux, November, 1974). Flows of the Madison River are regulated by releases from Hebgen Reservoir; however, Montana Power Company, in cooperation with the Montana Department of Fish and Game, provides sufficient releases to minimize damage to the downstream aquatic community.

WEST GALLATIN RIVER

Cutthroat and rainbow trout are the dominant fish species found in the headwaters and mountain tributaries of this stream, while rainbow and brown trout are predominant downstream of the mouth of the Gallatin Canyon. Mountain whitefish, sculpins, and three species of suckers are found throughout the drainage. Brook trout are found in many of the tributaries as well as in the mainstem (Marcoux, November, 1974).

Extensive dewatering and channel alterations to the West Gallatin River downstream of Gallatin Gateway to facilitate irrigation severely limits aquatic productivity of the stream (Marcoux, November 1974). Logging, road construction, and subdivision activities

on many tributaries, such as Squaw, Greek, Portal, and Hyalite creeks and on the West Fork, have caused sediment loads in the West Gallatin River to increase. Increased flows resulting from logging contribute to stream bottom scouring and channel migration, lessening the aquatic productivity of some tributaries (Marcoux, November, 1974).

EAST GALLATIN RIVER

Potentially one of the better trout streams in the Upper Missouri tributaries basin, the East Gallatin River has been subjected to many abuses which have degraded its fishery (Marcoux, November, 1974). Because of its proximity to Bozeman, effluent from the Bozeman sewage treatment plant is discharged to the East Gallatin. High sediment loads also degrade this stream. Subdivision activity on tributaries such as Bridger, Bear, Sourdough and Rocky creeks are potential problem areas. Logging has been extensive in several drainages tributary to the East Gallatin and is considered a major contributor of increased sediment yields (Marcoux, November, 1974).

X. WASTE DISCHARGE PERMITS

The Montana state program for issuing waste discharge permits is operated under authority of the Montana water pollution control law. Statutory authority to apply and enforce state compliance schedules in state permits are Sections 69-4806(3), 69-4808.2(1)(f)(1) and (2), 69-4820, 69-4820.1, and 69-4823, Revised Codes of Montana, 1947. The applicable rule is existing MAC 16-2.14(10)-S14460, Montana Pollutant Discharge Elimination System (MPDES), Section (2)(b)(ii) effective March 8, 1974.

Eleven municipal, one industrial, and four agricultural wastewater discharge permits have been issued by the state in the Upper Missouri tributaries basin (Table 22). The U. S. Environmental Protection Agency (EPA) issues waste discharge permits for federal facilities in Montana. Two NPDES permits (Table 22) have been issued in the basin. Dischargers not assigned a permit number had not made application as of July 15, 1975. Approximately 12 to 20 additional permits for agricultural discharges are anticipated. All municipalities on compliance schedules are expected to meet secondary treatment requirements by July 1, 1977. Facility descriptions and effluent characteristics are discussed in Section VI.

Federal permits are issued pursuant to the National Pollutant Discharge Elimination System (NPDES) created by the Federal Water Pollution Control Act Amendments of 1972 (FWPCAA of 1972). To eliminate the duplication of effort which formerly existed, Montana was given the authority to administer the NPDES program in Montana on June 10, 1974. Section 402 of the FWPCAA of 1972 provides that states with adequate water pollution control program elements may apply for and receive authority from EPA to issue permits under the NPDES in their own states. Montana made the necessary revisions to the state water pollution control laws during the 1973 legislative session to provide the statutory authority for administration of the aforementioned NPDES program in Montana. In addition,

the Board of Health and Environmental Sciences adopted a rule entitled the Montana Pollutant Discharge Elimination System (MPDES). The MPDES rule provides the additional program elements needed by the state to comply with rules and regulations promulgated by the administrator of EPA pursuant to Section 304(h) of the FWPCAA of 1972. Section 304(h) relates to the state program elements necessary to administer the NPDES program.

TABLE 22. MPDES PERMITS IN THE UPPER MISSOURI TRIBUTARIES BASIN
(Curent as of February 14, 1975)

Facility	MPDES Permit No.	Date Issued	Expiration Date	Compliance Schedule (Due Date)
Belgrade, MT Sewage Treatment Lagoon	MT-0021563	7/24/74	6/30/79	None required
Boulder, MT Sewage Treatment Lagoon	MT-0023060	8/30/74	6/30/79	Yes (12/30/75)
Bozeman, MT Sewage Treatment Plant	MT-0022608	7/24/74	6/30/79	Yes (6/18/75)
Dillon, MT Sewage Treatment Lagoon	MT-0021458	7/9/74	6/30/79	Yes (11/9/75)
Ennis, MT Sewage Treatment Lagoon	MT-0022136	1/24/74	12/31/76	Yes (5/24/75)
Ennis National Fish Hatchery, Ennis, MT	MT-0000523	2/28/75	12/31/76	Yes (6/28/75)
Bozeman Fish Cultural Development Center, Bozeman, MT	MT-0000515	2/28/75	12/31/79	Yes (6/28/75)
Gemco International, Inc. Basin, MT Industrial	MT-0023370	1/24/75	12/31/75	None
Manhattan, MT Sewage Treatment Lagoon	MT-0021857	8/30/74	6/30/79	Yes (12/30/75)

Facility	MPDES Permit No.	Date Issued	Expiration Date	Compliance Schedule (Due Date)
Sheridan, MT Sewage Treatment Lagoon	MT-0022098	8/30/74	6/30/79	Yes (12/30/74)
Three Forks, MT Collection System	MT-0020401	8/30/74	6/30/79	Yes (12/30/74)
Twin Bridges, MT Sewage Treatment Lagoon	MT-0020885	8/30/74	6/30/79	None required
Whitehall, MT Sewage Treatment Lagoon	MT-0020133	8/30/74	6/30/79	Yes (12/30/74)
Montana Power Company at Madison Dam near Ennis, MT	MT-0023167	8/30/74	6/30/79	None
Richard Batchelder Confined Swine Operation	F-1-H(1)	10/31/72	10/25/77	None
Eugene Horton Confined Swine Operation	F-6-H(1)	5/23/73	5/25/78	None
Russell Westlake Confined Swine Operation	MT-0029007	6/18/74	6/18/79	None
Walker Ranches	F-22-H	9/13/73	9/13/78	None
Virgil Smith & Son Feedlot	MT-0023400	Pending		None
East Bench Irrigation District	MT-0022934	Pending		None
High Line Canal Company	MT-0022845	Pending		None
Low Line Canal Company	MT-0022977	Pending		None

(1) Permit issued under Montana state permit system, superseded by MPDES.

XI. WASTE LOAD ALLOCATIONS

The Gallatin River drainage and portions of the Madison River and Grasshopper Creek are designated water quality limited segments (Table 23). Water quality limited streams and stream segments are those streams and stream segments for which application of greater than secondary treatment for municipalities and greater than best practicable treatment for industry probably will be needed to meet water quality standards.

There are no discharges in the Grasshopper Creek drainage, so no waste load allocations have been made. Grasshopper Creek from Bannack, Montana, to the Beaverhead River is classified as water quality limited because of toxic metals concentrations and turbidity due to past mine-mill activities. However, investigations indicate the problem is erosion and subsequent aquatic habitat destruction; past mine-mill activities do not appear to increase toxic metals levels (Section VIII).

The Madison River from the Montana-Wyoming border to the three forks of the Missouri is classified water quality limited because arsenic and fluoride concentrations exceed the USPHS (U. S. Public Health Service) limits for drinking water. Discharges to the Madison River do not affect background arsenic and fluoride concentrations, so no waste load allocations have been made.

The Gallatin River drainage is classified water quality limited because of possible dissolved oxygen and ammonia toxicity problems downstream of Bozeman's sewage treatment plant discharge. A waste load allocation study by Stuart, et.al. (July 25, 1974) concluded specific effluent limitations should be applied to the Bozeman plant (Table 24) to meet water quality standards for the East Gallatin River (Appendix B). These recommendations are considered in the permit (MT-0022608) for the Bozeman sewage treatment plant (Table 24).

Effluent from sewage treatment lagoons at Manhattan, Montana, is not expected to affect water quality in the Gallatin River drainage after secondary effluent

standards are met. Manhattan has made application for a planning grant to assess needs (Section VI). There are no other discharges in the Gallatin River drainage, so no waste load allocations have been made.

There are no other designated water quality limited segments in the Upper Missouri tributaries basin. However, the Boulder River from Basin, Montana, to the USGS station near Boulder, Montana (Table 11), plus the tributaries High Ore and Cataract Creeks, should be reclassified water quality limited stream segments. Toxic metals discharged from mine seeps upstream of Boulder, Montana, have affected severely growth and propagation of salmonids and associated aquatic life in the stream segments (Sections VI and VIII).

TABLE 23. UPPER MISSOURI TRIBUTARIES BASIN WATER QUALITY LIMITED STREAM SEGMENTS

Priority	Stream Segment (Geologic Location)	Comments
1	Gallatin River drainage (entire drainage)	Possible dissolved oxygen and ammonia toxicity problem downstream of City of Bozeman. Waste load allocation study completed by Stuart, et.al. (July 25, 1974). Section 208 planning grant received to study drainage.
2	Madison River (13S4E15 to 2N2E17)	High in arsenic and fluoride due to drainage from Yellowstone Park. Section 208 planning grant received to study drainage.
3	Grasshopper Creek (8S11W6 to 8S10W25)	High in turbidity due to past mining activities.

TABLE 24. FUTURE EFFLUENT LIMITATIONS FOR THE CITY OF BOZEMAN SEWAGE TREATMENT PLANT

Effective as soon as reasonable and practical but no later than July 1, 1977, the quality of effluent discharged by the facility shall, as a minimum, meet the limitations as set forth below:

	Average Effluent Concentration mg/l		Effluent Loadings Kg/day (lb/day)
	30 Consecutive Day period a/	7 Consecutive Day period b/	Monthly Average a/
BOD_5	30	45	600 (1318)
Tot. Susp. Solids	30	45	659 (1450)
Fecal Coliforms number/100 ml c/	200	400	
NH_3 (as N) - mg/l	-	3.5	60 (131)

The Total Residual Chlorine concentration shall be less than 0.05 mg/l in any grab sample. d/
The Oil and Grease concentration shall not exceed 10 mg/l in any grab sample. d/
pH - units shall remain between 6.0 and 9.0. d/

If not presently being complied with, for Discharge 001, effective as soon as reasonable and practical, but no later than July 1, 1977, the arithmetic mean of the BOD_5 and the Total Suspended Solids concentrations for effluent samples collected in a period of 30 consecutive days shall not exceed 15 percent of the arithmetic mean of the concentrations for influent samples collected at approximately the same times during the same period (85 percent removal). This is in addition to the concentration limitations on BOD_5 and Total Suspended Solids.

a/ For compliance purposes, this limitation shall be determined by the arithmetic mean of a minimum of three (3) consecutive samples taken on separate weeks in a 30-day period (minimum total of three (3) samples); not applicable to fecal coliforms - see footnote c/.

b/ For compliance purposes, this limitation shall be determined by the arithmetic mean of a minimum of three (3) consecutive samples taken on separate days in a 7-day period (minimum total of three (3) samples); not applicable to fecal coliforms - see footnote c/.

c/ For compliance purposes, averages for fecal coliforms shall be determined by the geometric mean of a minimum of three (3) consecutive grab samples taken during separate weeks in a 30-day period for the 30-day average, and during separate days in a 7-day period for the 7-day average (minimum total of three (3) samples).

d/ For compliance purposes, any single analysis and/or measurement beyond this limitation shall be considered a violation of the conditions of this permit.

XII. MANAGEMENT, STRATEGY AND SURVEILLANCE PLAN

A water quality management strategy should be designed to maintain and enhance water quality in the basin. The strategy also must consider requirements of all federal and state laws and regulations. The Federal Water Pollution Control Act Amendments of 1972 provide that for all discharges other than publicly owned treatment works, not later than July 1, 1977, effluent limitations are to be achieved which represent application of best practicable control technology currently available. All publicly owned treatment works must achieve secondary treatment or any more stringent limitations necessary to meet water quality standards by July 1, 1977.

The Upper Missouri tributaries basin contains nine percent of Montana's population or about 62,500 persons. There are 19 municipal water and wastewater treatment facilities and four industrial dischargers which discharge wastes to streams within the basin. Therefore, this basin is more complex than most others in Montana. However, only Bozeman is considered a major discharger.

From a basin strategy, management programs or plans can be developed and implemented. After plan development and implementation, water and wastes in the basin must be checked to determine the actual influence of the plan on basin waters. Water quality management is an iterative process; that is, a plan must be followed, the results checked and the program modified, and the results checked again. In the Upper Missouri tributaries basin, the basic strategy will consist of:

1. Municipal sewage treatment needs have been ranked according to priority (Section XIII). So, sewage treatment plants will be upgraded to meet secondary treatment standards. This will improve the quality of sewage treatment plant effluents and ensure compliance with Montana water quality standards.

2. At least one operation and maintenance inspection will be made annually of each municipal sewage treatment facility in the Upper Missouri tributaries basin. Critical installations will be provided additional inspections where possible. EPA form 7500-5 will be utilized for operation and

maintenance inspections. Facilities needing special assistance on operation and maintenance will be handled on a request basis. Assistance of EPA operation and maintenance personnel will be requested where long-term (two or three weeks) assistance will be required. The sewage treatment plant at Bozeman is the only plant in the Upper Missouri tributaries basin for which EPA assistance may be requested.

3. MPDES permits (Section X) will be issued to all dischargers. Most dischargers in the Upper Missouri tributaries basin have MPDES (or NPDES) permits.

4. Effluent from the Bozeman sewage treatment plant will be monitored by WQB personnel for compliance with applicable effluent limitations and compliance schedules at least once during fiscal year 1975. In addition, approximately 50 percent of the minor discharges under permit will be monitored for compliance during fiscal year 1975. Suspended residue, BOD_5, fecal coliforms, and flow will be monitored in all municipal discharges; residual chlorine will be measured where chlorination is provided. Eight waste discharge permits have been issued for confined livestock feeding operations and irrigation return flows in the Upper Missouri tributaries basin (Section VI). One permit for a confined livestock feeding operation is pending. Additional applications for MPDES permit in the basin are not anticipated.

5. It is the goal of the MDHES (Montana Department of Health and Environmental Sciences) to ensure best practical control technology and best available control technology effluent limitations are met by all municipal and industrial dischargers by July 1, 1977, and July 1, 1983, respectively, as required by the Federal Water Pollution Control Act Amendments of 1972, P.L. 92-500 and further defined by EPA regulations. It is also the goal of the MDHES to achieve no discharge of pollutants to state waters by July 1, 1985.

6. The Upper Missouri tributaries basin plan will be used as the basis for establishing priorities for surveillance, construction grants, and permit issuance.

7. Pollution from non-point sources, particularly sediment, is considered to be the principal

water pollution problem in Montana and the basin. Major non-point pollution problem areas in the basin (Section VI) which may need additional study are general erosion of stream banks and adjacent lands, high toxic metals levels in the Boulder River near Boulder, Montana, sediment yields due to the development of large recreational complexes and high sediment yields in the Gallatin, Madison, Red Rock, Ruby, Beaverhead, and Jefferson River drainages.

8. The Water Quality Bureau will participate with other regulatory agencies in controlling land use activities to abate potential and existing pollution problems. Specifically, SJR 0052, a joint resolution of the House and Senate passed by the 1974 legislature, states in part:

> *NOW, THEREFORE, BE IT RESOLVED BY THE SENATE AND THE HOUSE OF REPRESENTATIVES OF THE STATE OF MONTANA:*
>
> *That the Department of Natural Resources and Conservation and the Resource Conservation Advisory Council in cooperation with the Montana Association of Conservation Districts, the Department of Health and Environmental Sciences, and other interested parties make a thorough study of the sediment control problem, and existing legislation, and recommend to the 1975 Legislative Session appropriate legislation, including proposed rules and standards implementing such legislation, establishing a statewide program for the control of soil erosion and sediment damage.*

9. Oil spill inspection and reporting will be coordinated with the EPA, Department of Fish and Game, and the Oil and Gas Conservation Division of the Department of Natural Resources and Conservation.

10. Plans for subdivisions within the basin will be reviewed to assure water supplies and sewage disposal facilities are provided which comply with the state subdivision law and regulation. The law and regulation are administered by the Water Quality Bureau. The law requires approval of subdivision plats, plans, and specifications by the Department of Health and Environmental Sciences before filing with the county clerk and recorder.

11. Enforcement action will be taken to protect water quality. Under the state water pollution control law, enforcement remedies are contained in Sections 69-4820, 69-4820.1, 69-4821, 69-4824, 69-4824.1, and 69-4825. Penalty provisions are contained in Section 69-4824.

12. Municipalities, industries, and agricultural dischargers will be required to monitor their discharges. Frequency and parameters will be in accordance with MPDES permit conditions, and results will be submitted to the Water Quality Bureau and EPA. Authority to apply and enforce state compliance schedules in state permits is discussed in Section X. Authority to enforce stream water quality standards is discussed in Appendix B.

13. Selected water quality monitoring stations will be continued (Table 25) as a long-range water quality surveillance network. This network will be in addition to studies of identified problem areas (Section VI and VIII).

14. The strategy for future biological monitoring and semi-annual sediment sampling at long-term stations (Table 25) is being developed but is also contingent upon, as yet, undetermined funding.

15. A public education program on factors affecting water quality will be developed. Water quality and water quality related problems in the basin, in large part, appear caused by decisions made without consideration of long-term impacts on streams. This program will be directed particularly at riparian landowners.

16. The Boulder River from Basin, Montana to the USGS station near Boulder, Montana (Table 11), plus the High Ore and Cataract Creek drainages do not meet water quality standards for B-D_1 streams and should be reclassified water quality limited.

TABLE 25. UPPER MISSOURI TRIBUTARIES WATER QUALITY SURVEILLANCE STATIONS

Station Name	Agency and No.	Location[1]	Sampling Interval	Water Quality Parameters
Beaverhead River at Barretts, MT	USGS 06016000	8S 9W 19DC	Monthly	Dissolved: SiO_2, Fe, Ca, Mg, Na, K, Cl, F, NO_2 + NO_3, SO_4, PO_4, solids. Specific conductance, HCO_3, CO_3, pH, temperature, discharge.
Beaverhead River near Twin Bridges, MT	USGS 06018500	5S 7W 22DBC	Monthly	Dissolved: SiO_2, Fe, Ca, Mg, Na, K, SO_4, Cl, F, NO_2 + NO_3, PO_4, solids. Specific conductance, HCO_3, CO_3, pH, temperature, discharge, suspended sediment.
Bridger Creek at Federal Fish Hatchery near Bozeman, MT	WQB	1S 6E 34BCD	Quarterly	Ca, Mg, Na, HCO_3, CO_3, Cl, SO_4, NO_3, PO_4, K, pH, specific conductance, total and fecal coliforms, temperature, discharge, turbidity. Total recoverable: Fe, Mn, Cu, Cd, Zn, As.
East Gallatin River at State Highway 346 Bridge just above Thompson Creek	WQB	1N 4E 13D	Quarterly	Ca, Mg, Na, HCO_3, CO_3, Cl, SO_4, NO_3, PO_4, K, pH, specific conductance, total and fecal coliforms, temperature, discharge, turbidity. Total recoverable: Fe, Mn, Cu, Cd, Zn, As.

(1) See Appendix C.

XIII. MUNICIPAL FACILITIES INVESTMENTS

State water quality standards in the East Gallatin River may continue to be violated by effluent from Bozeman's sewage treatment plant after the application of secondary treatment. So, more stringent limitations which may require treatment beyond national secondary standards have been imposed. All other municipal discharges are expected to meet state water quality standards after the application of secondary treatment. Facilities in need of upgrading to meet secondary effluent standards are listed in Table 26 in order of priority.

TABLE 26. SEWAGE TREATMENT NEEDS IN THE UPPER MISSOURI TRIBUTARIES BASIN

Community	Needs Description	1990 Design Population	Cost Estimates		Status
Three Forks	Secondary treatment facility	1,424	Treatment . .	$ 218,000	Planning grant received
Big Sky (Gallatin Co. RSID 305)	Provide chlorination and filtration facilities	-	Treatment . . .	$152,000	Planning grant received
Bozeman	Correct infiltration problems; sewer improvements; provide secondary treatment	36,000	Treatment . . Sewers . . .	$3,200,000 1,720,000 $4,920,000	Planning grant received
Dillon	Correct infiltration problems; provide secondary treatment	5,685	Treatment and infiltration .	$440,000	Planning grant received
Boulder (town plus State Training School and Hospital)	Correct infiltration problems and provide secondary treatment	1,800	Treatment . . . Infiltration .	$250,000 12,000 $262,000	Planning grant received
Whitehall	Correct infiltration; provide secondary treatment	1,740	Treatment and infiltration .	$225,000	Planning grant received
Manhattan	Correct infiltration problems; sewer improvements; provide secondary treatment	1,000	Treatment . . Sewers . . .	$ 200,000 337,000 $ 537,000	Planning grant received
Sheridan	Correct infiltration; provide secondary treatment	730	Treatment and infiltration	$ 200,000	Planning grant received

Community	Needs Description	1990 Design Population	Cost Estimates		Status
Ennis	Correct infiltration problems; sewer improvements; provide secondary treatment	800	Treatment . . .	$150,000	Planning grant received
			Sewers . . .	105,000	
				$255,000	
Belgrade	Extend service area				
Willow Creek	Construct sewers and sewage treatment facilities			$400,000	No grant
Amsterdam-Churchill	Construct sewers and sewage treatment facilities			$800,000	No grant
Bozeman	Extend service area			$1,500,000	No grant
Dillon	Extend service area			$1,500,000	No grant
Sheridan	Extend service area			$1,500,000	No grant
Melrose	Extend service area			$1,500,000	No grant
Twin Bridges	Correct infiltration problems and provide secondary treatment	675	Treatment . .	$ 90,000	Not on fiscal year 1976 priority list
			Infiltration.	2,000	
				$ 92,000	

XIV. PLANNING NEEDS

Planning needs for the Upper Missouri tributaries basin relate almost exclusively to land use considerations (Table 27). Nonpoint pollution (Section VI) from adverse land uses is felt to be the major water pollution problem in Montana and the basin. Major areas in need of planning in the basin, therefore, are erosion of stream banks and erosion of adjacent lands.

Section 208 of the Federal Water Pollution Control Act Amendments of 1972 provides grants to areas having special water quality problems which extend over local jurisdictional boundaries to develop an overall plan for the area. As part of plan preparation, local governments within the designated area are expected to establish an agency or agencies for implementing the water quality management plans, and the implementing agency or agencies would be the only ones which could receive sewage treatment works construction grants. Blue Ribbons of the Big Sky Country Areawide Planning Organization (Gallatin and Madison River drainages) has received a Section 208 grant. Planning efforts will begin on or about July 1, 1975. The grant will provide funding for 24 months. No other areas in the Upper Missouri Tributaries basin have made application for Section 208 grants.

Definite funding will be necessary before planning for future biological monitoring and semi-annual sediment sampling at long-term stations (Table 25) can be completed.

TABLE 27. PLANNING NEEDS FOR WATER QUALITY AND WATER QUALITY RELATED PROBLEMS IN THE UPPER MISSOURI TRIBUTARIES BASIN

Problem Description	Priority for Future Study	Source	Remarks
Arsenic and fluoride levels in Madison River exceed 1962 U. S. Public Health Service limits	None	Thermal areas of Yellowstone National Park are probable sources based on available data.	Madison River would be unsuitable for domestic supply with existing arsenic and fluoride levels.
High toxic metals levels in Boulder River near Boulder, Montana	Moderate	Sources are extensive mining activity in watershed, particularly upstream of Boulder, Montana.	Preliminary study completed (Braico and Botz, December 9, 1974). Present activity level is low.
High sediment loads in Grasshopper Creek downstream of Bannack, Montana; limited salmonid population	Low	Most of the erosion appears to occur in the first four or five miles downstream of Bannack, Montana. Sediment probably due to channel instability due to past placer mining, overgrazing and tailings erosion (minor). Stream lies at bottom of narrow canyon, which has been extensively placered.	Conclusions based on Water Quality Bureau field investigation (July 11, 1973). Poor salmonid population probably due to extensive areas of shifting sand bottom caused by earlier placering.
High sediment yields to Big Sheep Creek via Muddy Creek near Dell, Montana	Low	Erosion occurs between mouth of Muddy Creek and confluence of Wilson and Sourdough creeks. Erosion probably is due to past overgrazing (as evidenced by recent sagebrush spraying) and poor road building practices. Water collected on uphill side of road is discharged through culvert to downhill side as point source where severe erosion is evident.	Conclusions based on Water Quality Bureau field investigation (July 12, 1974). Soil in drainage is almost exclusively fine-grained with little sand and gravel evident.

Problem Description	Priority for Future Study	Source	Remarks
Moderate sediment yields in East Gallatin River	Moderate	Apparent cause is agricultural encroachment of stream bank. Stream flows through area of easily eroded soil.	Conclusions based on study by Stuart, et.al. (1974) and field observations by author (July, 1971).
Moderate sediment loads to stream within the basin from past mining activites	Moderate	Tailings areas, overburden piles, and unstable channel conditions created by dredge mining. Problems are severe in the Boulder River drainage and in Grasshopper Creek (Section VIII). Similar problems are likely in other mining areas in the basin.	Areas which are generally known are discussed in Section VIII; however, available data is not extensive. Data collected in Montana Bureau of Mines and Geology study (March, 1974) was during low water year and was not conclusive.
Moderate sediment loads to the Beaverhead River downstream of Clark Canyon Dam.	Moderate	Observations by Peterson (July 8, 1974) indicate hydrographic modifications of the Beaverhead River by Clark Canyon Dam may be a major reason for stream bank caving on the Beaverhead River.	Portions of the Beaverhead River channel between the dam and Barrett's diversion have been riprapped since construction of the dam.
Moderate sediment loads to the Gallatin, Big Hole and Jefferson rivers by man-induced stream channel alterations	Moderate	Stream channel alterations for agricultural purposes are believed common in the basin.	Dunkle (1955) discussed channel changes to the West Gallatin River by agricultural interests. Channel manipulations of the Big Hole River was discussed by Peterson (February 15, 1974).
High sediment yields from Red Rock River drainage upstream of Lima Reservoir	High	Sources are eroding soils in the watershed due to overgrazing and irrigation practices. Sediment is deposited in the streams and lakes of the Red Rock Lakes National Wildlife Refuge.	Conclusions based on personal communication (E. D. Stropps to D. M. Zollman, January 8, 1974).

Problem Description	Priority for Future Study	Source	Remarks
High sediment yields due to various logging activities	Moderate	Poorly constructed roads, creation of unstable land masses and unprotected slopes, skidding and yarding in natural drainages.	Logging activities on Burlington Northern lands in the Hyalite Creek drainage south of Bozeman, Montana, have resulted in a land flow (Montana Department of Health and Environmental Sciences, February 7, 1975). Similar situations likely have occurred in other drainages.

A P P E N D I X

APPENDIX A

GLOSSARY

Symbol	Definition
lbs/day	pounds per day
mgd	million gallons per day
sq. ft.	square feet
BOD_5	five-day biochemical oxygen demand
lbs/capita/day	pounds per capita per day
gpcd	gallons per capita per day
TR	total recoverable
gpm	gallons per minute
USPHS	U. S. Public Health Service
$\leq$	less than or equal to
$\geq$	greater than or equal to
JTU	Jackson turbidity units
mg/l	milligrams per liter
FWPCAA	Federal Water Pollution Control Act Amendments
WQB	Water Quality Bureau
EPA	U. S. Environmental Protection Agency
MPDES	Montana Pollutant Discharge Elimination System
NPDES	National Pollutant Discharge Elimination System

Symbol	Definition
USGS	U. S. Geological Survey

APPENDIX B

MONTANA STATE DEPARTMENT OF HEALTH
AND
ENVIRONMENTAL SCIENCES

MAC 16-2.14(10)-S14480 WATER QUALITY STANDARDS

(1) Policy statement. The following standards are adopted to establish maximum allowable changes in water quality and establish limits for pollutants which affect prescribed beneficial uses of state waters. The department adopts as a rule the policy that best practicable treatment and control of waste, activity and flow is to be provided to maintain dissolved oxygen and overall water quality at the highest possible levels, and water temperatures, coliform bacteria concentrations, dissolved chemical substances, toxic materials, radioactivity, turbidities, color, odor and other deleterious substances at the lowest possible levels.

(2) Application of standards. The water quality standards are composed of water-use classifications [section (4)], water-use descriptions and specific water quality criteria [section (5)], and general water quality criteria [section (6)].

(a) General water quality criteria apply to all state waters except where in this rule specific water quality criteria are more applicable to a specific water-use classification.

(b) In order to carry out the objective of the rule, existing discharges to state waters shall be brought into compliance with the standards as soon as practicable, and in no case later than three years from the effective date of the rule.

(3) Definitions. Unless statutory definition or the context otherwise requires in this rule:

"Conduit" means any artificial or natural duct, either open or closed, for conveying liquids or other fluids.

"Dewatered stream" means a perennial or intermittent stream whose water has been removed for one or more beneficial uses.

"EPA" means the U. S. Environmental Protection Agency.

"Intermittent stream" means a stream or portion of a stream that flows only in direct response to precipitation; it receives little or no water from springs and no long-continued supply from melting snow or other sources.

"Naturally occurring" means conditions or material present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil and water conservation practices have been applied. Conditions resulting from dams in existence as of July 1, 1971 are natural.

"Mixing zone" means that volume of state water wherein any pollutant may exceed allowable water quality standards.

"Pesticide" means insecticides, herbicides, rodenticides, fungicides or any substance or mixture of substances intended for preventing, destroying, controlling, repelling, altering life processes, or mitigating any insects, rodents, nematodes, fungi, weeds and other forms of plant or animal life.

"Residue" means oils, floating solids and sludge deposits.

"Sediment" means solid material settled from suspension in a liquid; mineral or organic solid material that is being transported or has been moved from its site of origin by air, water or ice and has come to rest on the earth's surface, either above or below sea level; or inorganic or organic particles originating from weathering, chemical precipitation or biological activity.

"Settleable solids" means inorganic or organic particles that are being transported or have been transported by water from the site or sites of origin and are settled or are capable of being settled from suspension.

"Sewer" means a pipe or conduit that carries wastewater or drainage water.

"State waters" means any body of water, irrigation system or drainage system, either surface or underground. This section shall not apply to irrigation waters where the waters are used up within the irrigation system and said waters are not returned to any other state waters. The term "state waters" as used in this rule does not include underground water.

"Storm sewer" or "storm drain" means a sewer that carries storm water and surface water, street wash and other wash waters, or drainage but excludes sewage and industrial wastes.

"True color" means the color of water from which the turbidity has been removed.

"Turbidity" means a condition in water or wastewater caused by the presence of suspended matter resulting in the scattering and absorption of light rays.

(4) Water-use classifications.

MISSOURI BASIN

Missouri River Drainage

Missouri River:

Missouri River drainage to the Sun River in Great Falls except tributaries listed below B-D1

East Gallatin River (mainstem) (tributary to the Gallatin River, tributary to the Missouri River) from Montana Highway No. 293 crossing about one-half mile north of Bozeman to but excluding Dry Creek about five miles east of Manhattan . . . B-D2

Remainder of East Gallatin River drainage except the tributaries listed below . . . . . B-D_1

Lyman and Sourdough (Bozeman) Creek drainages to the Bozeman water supply intake . . . . . A-Closed

Remainder of the Lyman and Sourdough Creek drainages . . . B-D_1

Hyalite Creek drainage to the Bozeman water supply intake . A-Open-D_1

Remainder of Hyalite Creek drainage . . . . . B-D_1

Big Hole River drainage (tributary to the Jefferson River, tributary to the Missouri River) above Divide . . . . . A-Open-D_1

Remainder of the Big Hole drainage . . . . . B-D_1

Rattlesnake Creek drainage (tributary to the Beaverhead River, tributary to the Jefferson River) to the Dillon water supply intake . . . . . A-Open-D_1

Remainder of Rattlesnake Creek drainage . . . . . B-D_1

Indian Creek drainage (tributary to the Ruby River, tributary to the Beaverhead River) to the Sheridan water supply intake . . A-Open-D_1

Remainder of Indian Creek drainage . . . . . B-D_1

Basin Creek drainage (tributary to the Boulder River, tributary to the Jefferson River) to the Basin water supply intake . . . . . A-Open-D_1

Remainder of Basin Creek drainage . . . . . B-D_1

(5) Water-use description and specific water quality criteria.

(a) General. Specific water quality criteria, along with criteria in section (6) protect the beneficial water uses set forth in the water-use descriptions for the following classifications of water. Criteria for organisms of the coliform group are based on a minimum of five samples obtained during separate 24-hour periods during any consecutive 30-day period analyzed by the most probable number or equivalent membrane filter methods. The metal limits on the Clark Fork River [section (6)] are to govern when this section (5) imposes a conflicting requirement with that criteria.

(b) A-Closed classification.

(i) Water-use description. Water supply for drinking, culinary and food processing purposes suitable for use after simple disinfection. Public access and activities such as livestock grazing and timber harvest are to be controlled by the utility owner under conditions prescribed and orders issued by the department. Only those waters on which access is presently controlled by the utility owner have been classified as A-Closed. If other uses are permitted, the waters are to be reclassified A-Open-D_1.

(ii) Specific water quality criteria.

(aa) The average number of organisms in the coliform group is not to exceed 50 per 100 milliliters.

(ab) Dissolved oxygen criteria are not applicable for the classification.

(ac) No change from natural pH is allowed.

(ad) No increase above naturally occurring turbidity is allowed.

(ae) No increase above naturally occurring water temperature is allowed.

(af) No increases above naturally occurring concentrations of sediment, settleable solids or residues, which adversely affect the use indicated, are allowed.

(ag) No increases of toxic or other deleterious substances, pesticides and organic and inorganic materials including heavy metals, above naturally occurring concentrations, are allowed.

(ah) No wastes are allowed which increase radioactivity above natural background levels.

(c) A-Open-D_1 classification.

(i) Water-use description. Water supply for drinking, culinary and food processing purposes suitable for use after simple disinfection and removal of naturally present impurities. Water quality is to be maintained suitable for bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply. Where the waters are used for swimming or other water-contact sports, analyses are to be made by the utility owner and the department to determine if a higher degree of treatment is required for potable water use.

Waters, if shown to meet the A-Closed criteria, may be so classified by the department at the request of the utility owner. State waters within the boundaries of national parks and nationally designated wild, wilderness or primitive areas in the state are classified A-Open-D_1 except those adjacent to developed areas such as Snyder Creek through the community of Lake McDonald and Swiftcurrent Creek below the Many Glacier Chalet, both in Glacier National Park. Also, Georgetown, Flathead and Whitefish lakes and Lake Mary Ronan are classified A-Open-D_1 as are some streams presently used for domestic water supply.

(ii) Specific water quality criteria.

(aa) The average number of organisms in the coliform group is not to exceed 50 per 100 milliliters where demonstrated to be the result of domestic sewage.

(ab) Dissolved oxygen concentration is not to be reduced below 7.0 milligrams per liter.

(ac) Induced variation of hydrogen ion concentration (pH) within the range of 6.5 to 8.5 is to be less than 0.5 pH unit. Natural pH outside this range is to be maintained without change. Natural pH above 7.0 is to be maintained above 7.0.

(ad) No increase above naturally occurring turbidity is allowed.

(ae) A 1° F maximum increase above naturally occurring water temperature is allowed within the range of 32° F to 66° F; within the naturally occurring range of 66° F to 66.5° F, no discharge is allowed which will cause the water temperature to exceed 67° F; and where the naturally occurring water temperature is 66.5° F or greater, the maximum allowable increase in water temperature is 0.5° F. A 2° F per hour maximum decrease below naturally occurring water temperature is allowed when the water temperature is above 55° F, and a 2° F maximum decrease below naturally occurring water temperature is allowed within the range of 55° F to 32° F.

(af) No increases above naturally occurring concentrations of sediment, settleable solids or residues, which adversely affect the use indicated, are allowed.

(ag) Concentrations of toxic or other deleterious substances, pesticides and organic and inorganic materials including heavy metals, after treatment for domestic use, are not to exceed the recommended limits established in the 1962 U. S. Public Health Service Drinking Water Standards or subsequent editions; an increase of more than 10 percent of the concentration present in the receiving water is not allowed; maximum allowable concentrations are to be less than acute or chronic problem levels as revealed by bioassay or other methods.

(ah) True color is not to be increased more than two units above naturally occurring color.

(d) B-D1 classification.

(i) Water-use description. The quality is to be maintained suitable for drinking, culinary and food processing purposes after adequate treatment equal to coagulation, sedimentation, filtration, disinfection and any additional treatment necessary to remove naturally present impurities; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

(ii) Specific water quality criteria.

(aa) The average number of organisms in the fecal coliform group is not to exceed 200 per 100 milliliters, nor are 10 percent of the total samples during any 30-day period to exceed 400 fecal coliforms per 100 milliliters. The average number of organisms in the coliform group is not to exceed 1,000 per 100 milliliters, nor are 20 percent of the samples to exceed 1,000 coliforms per 100 milliliters during any 30-day period.

(ab) Dissolved oxygen concentration is not to be reduced below 7.0 milligrams per liter.

(ac) Induced variation of hydrogen ion concentration (pH) within the range of 6.5 to 8.5 is to be less than 0.5 pH unit. Natural pH outside this range is to be maintained without change. Natural pH above 7.0 is to be maintained above 7.0.

(ad) The maximum allowable increase above naturally occurring turbidity is 5 Jackson Candle Units except as is permitted in the general water quality criteria.

(ae) A 1° F maximum increase above naturally occurring water temperature is allowed within the range of 32° F to 66° F; within the naturally occurring range of 66° F to 66.5° F, no discharge is allowed which will cause the water temperature to exceed 67° F; and where the naturally occurring water temperature is 66.5° F or greater, the maximum allowable increase in water temperature is 0.5° F. A 2° F per hour maximum decrease below naturally occurring water temperature is allowed when the water temperature is above 55° F, and a 2° F maximum decrease below naturally occurring water temperature is allowed within the range of 55° F to 32° F.

This applies to all waters in the state classified B-D_1 except for Prickly Pear Creek from McClellan Creek to the Montana Highway No. 433 crossing where a 2° F maximum increase above naturally occurring water temperature is allowed within the range of 32° F to 65° F; within the naturally occurring range of 65° F to 66.5° F, no discharge is allowed which will cause the water temperature to exceed 67° F; and where the naturally occurring water temperature is 66.5° F or greater, the maximum allowable increase in water temperature is 0.5° F.

(af) No increases above naturally occurring concentrations of sediment, settleable solids or residues, which adversely affect the use indicated, are allowed.

(ag) Concentrations of toxic or other deleterious substances, pesticides and organic and inorganic materials including heavy metals, after treatment for domestic use, are not to exceed the recommended limits contained in the 1962 U. S. Public Health Service Drinking Water Standards or subsequent editions; also, maximum allowable concentrations are to be less than acute or chronic problem levels as revealed by bioassay or other methods.

(ah) True color is not to be increased more than five units above naturally occurring color.

(c) B-D_2 classification.

(i) Water-use description. The quality is to be maintained suitable for drinking, culinary and food processing purposes after adequate treatment equal to coagulation, sedimentation, filtration, disinfection and any additional treatment necessary to remove naturally present impurities; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

(ii) Specific water quality criteria.

(aa) The average number of organisms in the fecal coliform group is not to exceed 200 per 100 milliliters nor are 10 percent of the total samples during any 30-day period to exceed 400 fecal coliforms per 100 milliliters. The average number of organisms in the coliform group is not to exceed 1,000 per 100 milliliters nor are 20 percent of the samples to exceed 1,000 coliforms per 100 milliliters during any 30-day period.

(ab) Dissolved oxygen concentration is not to be reduced below 7.0 milligrams per liter from October 1 through June 1 nor below 6.0 milligrams per liter from June 2 through September 30.

(ac) Induced variation of hydrogen ion concentration (pH) within the range of 6.5 to 9.0 is to be less than 0.5 pH unit. Natural pH outside this range is to be maintained without change. Natural pH above 7.0 is to be maintained above 7.0.

(ad) The maximum allowable increase above naturally occurring turbidity is 10 Jackson Candle Units, except as is permitted in the general water quality criteria.

(ae) A 1° F maximum increase above naturally occurring water temperature is allowed within the range of 32° F to 66° F; within the naturally occurring range of 66° F to 66.5° F, no discharge is allowed which will cause the water temperature to exceed 67° F; and where the naturally occurring water temperature is 66.5° F or greater, the maximum allowable increase in water temperature is 0.5° F. A 2° F per hour maximum decrease below naturally occurring water temperature is allowed when the water temperature is above 55° F, and a 2° F maximum decrease below naturally occurring water temperature is allowed within the range of 55° F to 32° F.

(af) No increases above naturally occurring concentrations of sediment, settleable solids or residues, which adversely affect the use indicated, are allowed.

(ag) Concentrations of toxic or other deleterious substances, pesticides and organic and inorganic materials including heavy metals, after treatment for domestic use, are not to exceed the recommended limits contained in the 1962 U. S. Public Health Service Drinking Water Standards or subsequent editions; also, maximum allowable concentrations are to be less than acute or chronic problem levels as revealed by bioassay or other methods.

(ah) True color is not to be increased more than five units above naturally occurring color.

(6) General water quality criteria.

(a) The degree of waste treatment required to restore and maintain the standards is to be determined by the department and is to be based on the following.

(i) The state's policy of nondegradation of existing high water quality as described in Section 69-4808.2, R.C.M. 1947.

(ii) Present and anticipated beneficial uses of the receiving water.

(iii) The quality and nature of flow of the receiving water.

(iv) The quantity and quality of the sewage, industrial waste or other waste to be treated.

(v) The presence or absence of other sources of pollution on the same watershed.

(b) Sewage is to receive a minimum of secondary treatment as defined by EPA in accordance with requirements as set forth in the Federal Water Pollution Control Act Amendments of 1972.

(c) Industrial waste is to receive, as a minimum, treatment equivalent to the best practicable control technology currently available (BPCT) as defined by EPA. In cases where BPCT is not defined by EPA, industrial waste is to receive, after maximum practicable in-plant control, a minimum of secondary treatment or equivalent.

(d) For design of disposal systems, stream flow dilution requirements are to be based on minimum consecutive seven-day average flow which may be expected to occur on the average of once in ten years. When dilution flows are less than the above design flow at a point discharge, the discharge is to be governed by the permit conditions developed for the discharge through the waste discharge permit program.

(e) State surface waters are to be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will:

(i) Settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines.

(ii) Create floating debris, scum, a visible oil film (or be present in concentrations at or in excess of 10 milligrams per liter) or globules of grease or other floating materials.

(iii) Produce odors, colors or other conditions as to create a nuisance or render undesirable tastes to fish flesh or make fish inedible.

(iv) Create concentrations or combinations of materials which are toxic or harmful to human, animal, plant or aquatic life.

(v) Create conditions which produce undesirable aquatic life.

(f) No wastes are to be discharged and no activities conducted such that the wastes or activities, either alone or in combination with other wastes or activities, will violate, or can reasonably be expected to violate, any of the standards; (e.g., in a reach of stream classified B-D_1, the total allowable cumulative increase to naturally occurring turbidity conditions in the reach is 5 Jackson Candle Units).

(g) No wastes are to be discharged and no activities conducted which, either alone or in combination with other wastes or activities, will cause turbidities to exceed those allowed by specific water quality criteria; provided, short-term activities necessary to accommodate essential dredging, channel or bank alterations, stream diversions or other construction where turbidities in excess of the criteria are unavoidable, may be authorized by the department under conditions as it may prescribe.

(h) Methods of sample collection, preservation and analysis used to determine compliance with the standards are to be in accordance with the latest edition of Standard Methods for the Examination of Water and Wastewater published by the American Public Health Association or in accordance with tests or procedures that have been found to be equally or more applicable.

(i) For operations of existing water impoundments that cause conditions harmful to prescribed beneficial uses of state waters, it is to be demonstrated to the satisfaction of the department that continued operations will be done in the best practicable manner to minimize harmful effects and will not violate state laws or department rules. New water impoundments shall be designed to provide temperature variations in discharging water that maintain or enhance the existing propagating fishery and associated aquatic life. As a guide, the following temperature variations are recommended: Continuously less than 40° F during the months of January and February, and continuously greater than 44° F during the months of June through September.

(j) Ponds for waste treatment purposes are not to be located in drainage ways where the volume of drainage water from a 10-year storm entering the ponds exceeds one-half the volume of the pond; provided that, subject to approval by the department as to design and maintenance, ponds located in drainage ways for the express purpose of containing emergency oil spills are permitted.

(k) Dumping of snow from municipal and/or parking lot snow removal activities into waters of the state is prohibited without a permit from the department.

(l) Existing discharges to state waters will be entitled a mixing zone as determined by the department.

(m) Until such time as minimum stream flows are established for dewatered streams, the minimum treatment requirements for discharges to dewatered receiving streams are to be no less than the minimum treatment requirements prescribed.

(n) Treatment requirements for discharges to intermittent streams are to be no less than the minimum treatment requirements prescribed.

(o) Pollution resulting from storm drainage, storm sewer discharges, and non-point sources, including irrigation practices, road building, construction, logging practices, overgrazing and other practices, are to be eliminated or minimized as ordered by the department.

(p) Application of pesticides in or adjacent to state waters is to be in compliance with the labeled direction, and in accordance with provisions of the Montana Pesticides Act (Title 27, Chapter 2, R.C.M. 1947) and the Federal Environmental Pesticides Control Act (Public Law 92-516). Excess pesticides and pesticide containers are not to be disposed of in a manner or in a location where they are likely to pollute state waters.

(q) The following radiological criteria shall apply to all waters except those classified as A-Closed:

(i) The average dissolved concentrations (including the naturally occurring or background contribution) of iodine 131, radium-226, strontium-89, strontium-90 and tritium are not to exceed the following concentration limits:

Iodine-131	5 pCi/L
Radium-226	1 pCi/L
Strontium-89	100 pCi/L
Strontium-90	10 pCi/L
Tritium	3,000 pCi/L

For all other radionuclides, the average dissolved concentration limits are to be 1/150 of the corresponding maximum permissible concentration in water for continuous occupational exposure as recommended by the National Committee on Radiation Protection (National Bureau of Standards Handbook 69 or subsequent revisions.)

(ii) For a mixture of radionuclides, the following relationship is to be satisfied:

$$\frac{C_1}{L_1} + \frac{C_2}{L_2} \cdot \cdot \cdot + \frac{C_n}{L_n} \leq 1.00$$

C denotes the average concentration of the respective radionuclide, and L denotes its concentration limit.

(iii) Where alpha emitters, strontium-90, radium-228, iodine-129, iodine-130 and lead-210 are known to be absent, routine analyses for dissolved gross beta radioactivity (excluding potassium-40 contribution) may be employed to monitor and show compliance with this criterion (except for tritium) as long as the gross concentration does not exceed 100 pCi/L. When these conditions are not met, routine quantitative analyses of individual radionuclides are to be performed to show compliance. Except in cases where tritium from other than natural sources is known to be absent, routine

tritium analyses are to be performed to show compliance. (Note: "Absence" means a negligibly small fraction of the specific concentration limit, where the limit for unidentified alpha emitters is taken as the limit for radium-226.)

(iv) For radionuclides associated with suspended material in transport, the average concentration limits are to be 1/150 of the corresponding maximum permissible concentration in water (insoluble form) for continuous occupational exposure as recommended by the National Committee on Radiation Protection. In-stream sedimentation of these materials is not to produce solids beds that are not in compliance with subsections (q) (i) and (q) (ii) (because of leaching) and/or excessive accumulation in native flora and fauna.

(v) Average concentrations are to be computed from monitoring data acquired during the previous 12 months; maximum concentrations are not to exceed three times the average concentration limits specified.

(vi) Variances from concentration limits specified will be permitted only if the contributing source is non-controllable or a natural source. Best available treatment must be provided for man-made discharges, and the exposure received by affected population groups must be within established dose limits.

(r) No wastes are to be discharged and no activities conducted which, either alone or in combination with other wastes or activities, will result in the dissolved gas content relative to the water surface to exceed 110 percent of saturation.

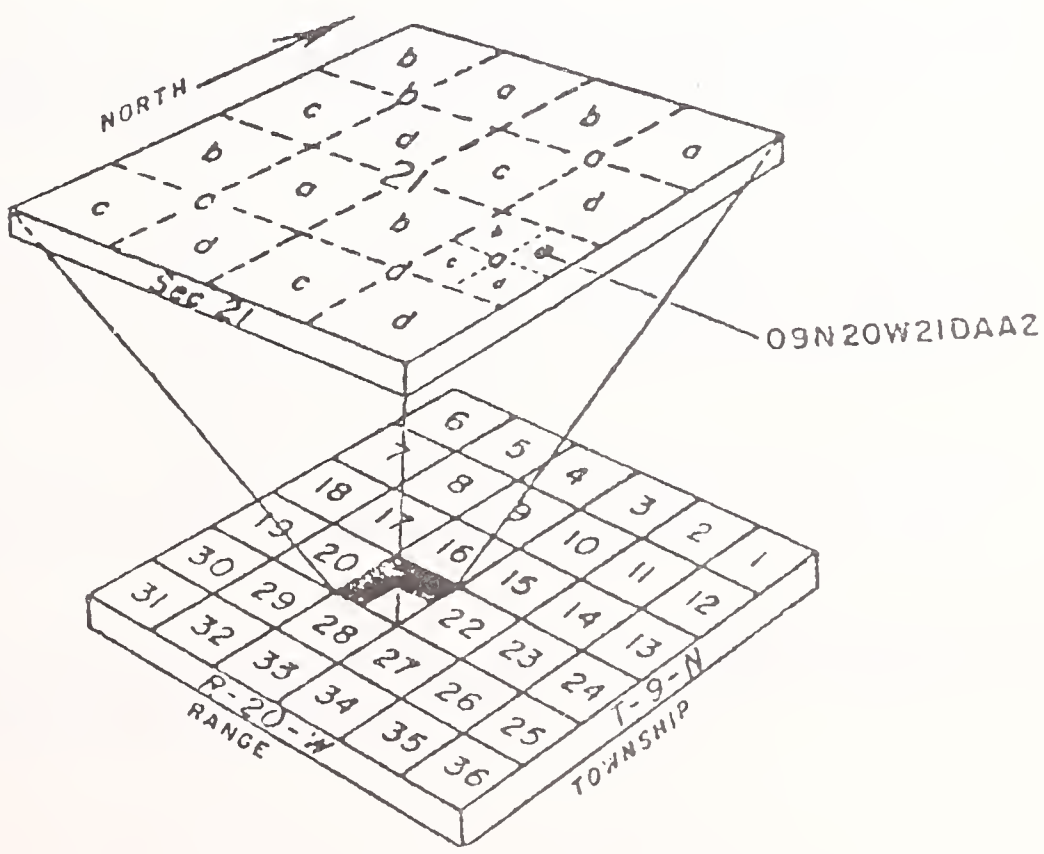
(s) Bioassay median tolerance concentrations are to be based on latest available research results for the materials, by bioassay tests procedures for simulating actual stream conditions as set forth in the latest edition of Standard Methods for the Examination of Water and Wastewater published by the American Public Health Association, or in accordance with tests or analytical procedures that have been found to be equal or more applicable by EPA. Bioassay studies are to be made using the most sensitive local species and life stages of economic or ecological importance; provided other species whose relative sensitivity is known may be used when there is difficulty in providing the most sensitive species in sufficient numbers.

When specific application factors are not available, the factor is to be determined by using methods listed in Water Quality Criteria published by the Federal Water Pollution Control Administration (1968), or by using other methods accepted as equal or applicable by EPA.

APPENDIX C

SYSTEM FOR GEOGRAPHIC LOCATION OF FEATURES

Wells, springs, water-sampling locations, and stream-gaging locations are assigned numbers based on the system of land subdivision used by the U. S. Bureau of Land Management. The number consists of twelve characters and describes the location by township, range, section, and position within the section. The figure below illustrates the numbering method. The first three characters of the number give the township, the next three characters the range The next two numbers give the section number within the township, and the next three letters describe the location within the quarter section (160-acre tract) and the quarter-quarter section (40-acre tract), and the quarter-quarter-quarte section (10-acre tract). These subdivisions of the 640-acre section are designated a, b, c, and d in a counterclockwise direction, beginning in the northeast quadrant. If there is more than one feature in a 10-acre tract, consecuti digits beginning with 2 are added to the number. For example, if a water-quali sample was collected in sec.21,T.9N.,R20W, it would be numbered 09N20W21DAA2. The letters DAA indicate that the well is in the NE¼ of the NE¼ of the SE¼, and the number 2 following the letters DAA indicates there is more than one water-quality sampling location in this 10-acre tract.



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PUBLIC HEARING

On April 2, 1975, at 7:00 p.m., a public hearing was held in the Community Room of the Gallatin County Courthouse, Bozeman, Montana. A taped record of the hearing was made by the Water Quality Bureau. There were no written comments on the Upper Missouri Tributaries Water Quality Inventory and Management Plan submitted at the hearing, and there were no formal oral comments given when requested by the hearings officer. Participants in the hearing informally discussed the plan. An additional 30 days were allowed for submission of written comments on the plan.

Comments and corrections noted by the U. S. Geological Survey and the Montana Environmental Quality Council have been incorporated into this final report. Comments by the Montana Department of Fish and Game are:

> *There are two areas that we should discuss with the Department of Health personnel regarding priority planning (see page 133 and 134 of the report).*
>
> *The Madison River is one of our most significant fisheries, therefore high priority should be given to minimizing any accelerated erosion and sedimentation problems on such tributaries as the West Fork and Cabin and Beaver Creeks.*
>
> *The East Gallatin River is another that has considerable potential as a fishery. However, it has many water quality problems. Due to its size and fishery potential, it should also be given high priority.*
>
> *Perhaps you could discuss this with Board of Health personnel. I also believe we should submit this in writing.*
>
> *It would also be desirable to implement suspended sediment monitoring at the Beaverhead River Barretts Station to identify possible increases in sedimentation rates between that station and the one at Twin Bridges. There is a noticeable decrease in trout populations between these points. Heavy sediment disposition is very obvious in the lower Beaverhead and this could provide us with an indication of the amounts entering from above Barretts.*

No additional comments were received.

The hearing notice was posted 30 days prior to the hearing, and notices were published as required by state regulations. Letters were sent to all persons, organizations, and groups which were thought to have an interest in this matter.